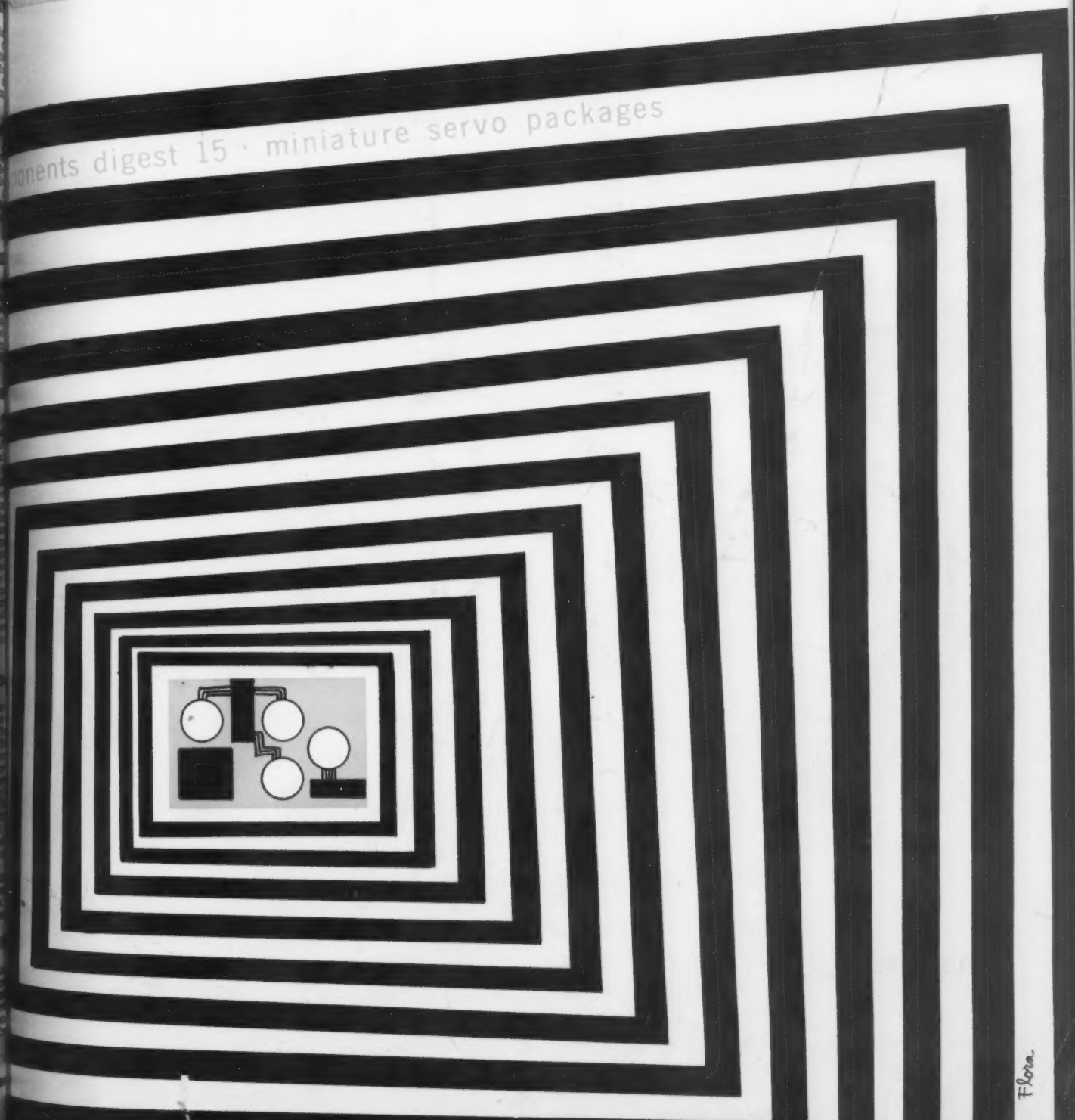
R.E. Carroll, Asst. Dir.
The University of Michigan
Ann Arbor, Michigan

ELECTROMECHANICAL

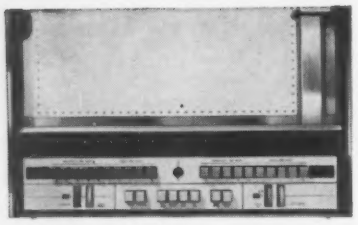
components & systems DESIGN

JUNE 1960

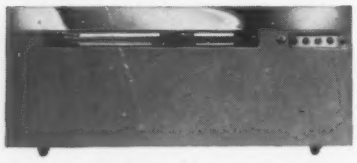
components digest 15 · miniature servo packages



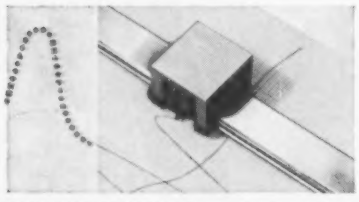
Flora



PUSH BUTTON PANEL controls operations rapidly, even at remote locations.

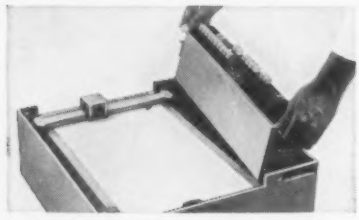


FLAT VACUUM PLATEN assures positive hold down of roll or sheet paper up to 12¼" width. Plot area, standard 10x15".

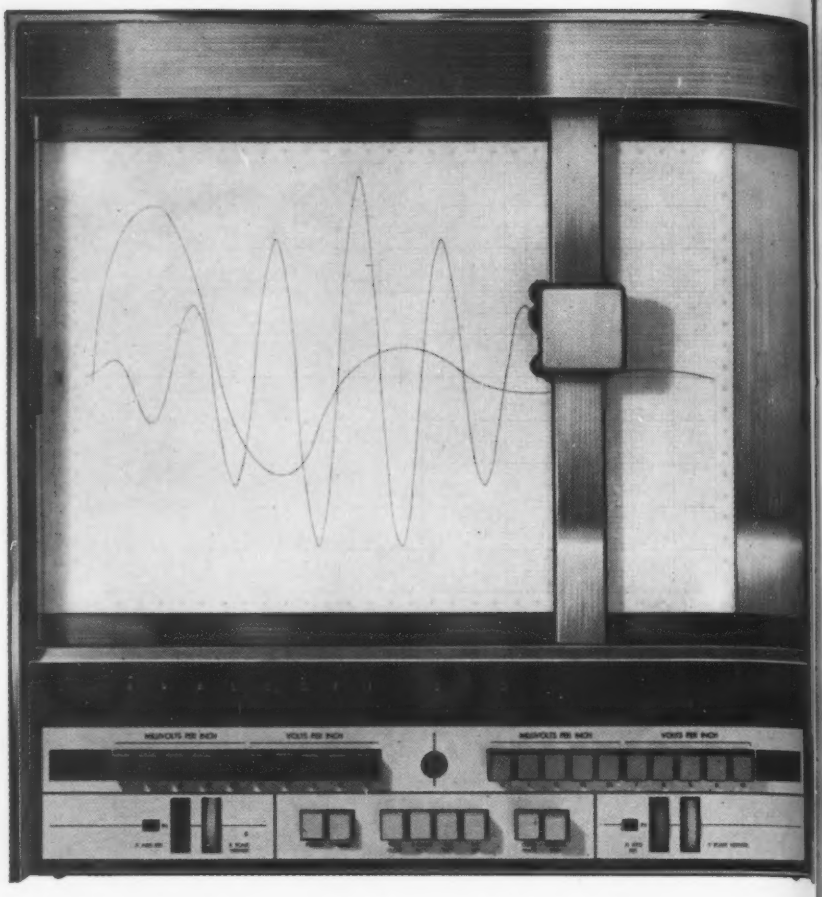


PRINTING FEATURES: Multiple symbol printing head—12 symbols...self contained ink supply.

Pen System—capillary action; splatter-proof. Point joiner available.



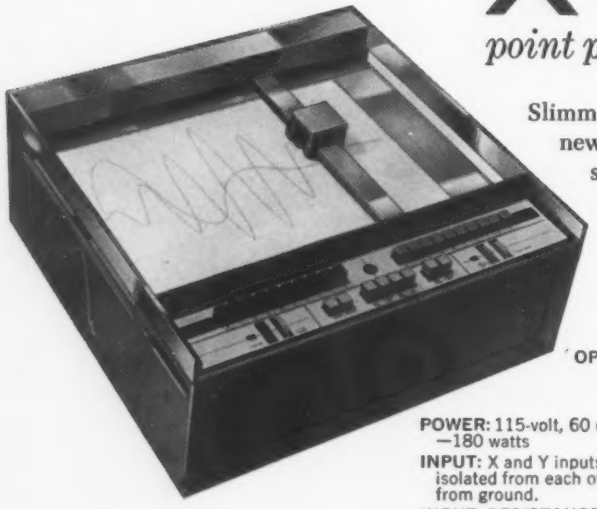
INTERCHANGEABLE MODULES add versatility...interchange with basic control section.



engineered for ease of operation...new

LIBRASCOPE X·Y PLOTTER

point plotting or continuous trace



Slimmer, flatter, push-button fast...Librascope's newest, most advanced plotter is the result of personally-conducted field research by Librascope engineers. Compact design permits rack mounting in groups, saves desk space. Many new conveniences have been added to answer *your* needs.

OPERATING INFORMATION

POWER: 115-volt, 60 cycle —180 watts

INPUT: X and Y inputs isolated from each other and from ground.

INPUT RESISTANCE: 2 megohms nominal on most scales. 1 megohm per volt on .5 millivolts per inch to .1 volts per inch scales.

INPUT SENSITIVITY: .5 millivolts per inch to 50 volts per inch with calibrated push button scales at .5, .1, 5, 10 and 50 millivolts per inch and .1, .5, 1, 5 and 10 volts per inch. Vernier controls permit continuous sensitivity adjustment between fixed scales, permitting full scale plotting for any sensitivity.

ACCURACY: Static .1%, dynamic .2% at 10" per second.

PLOTTER CALIBRATION ACCURACY: .05% on all scales.

SLEWING SPEED: 20" per second.

For full details — dimensions, applications, list of accessory equipment, call our Sales Engineering Department or send for illustrated brochure on Model 210, XY Plotter.

For information on career opportunities at Librascope, write Glen Seltzer, Employment Manager.

GP LI 9-20

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CIRCLE NO. 1 ON INQUIRY CARD

ELECTROMECHANICAL components & systems DESIGN

The Sourcebook of Design Ideas in Applied Electromechanics

JUNE 1960 • VOL. 4 NO. 6

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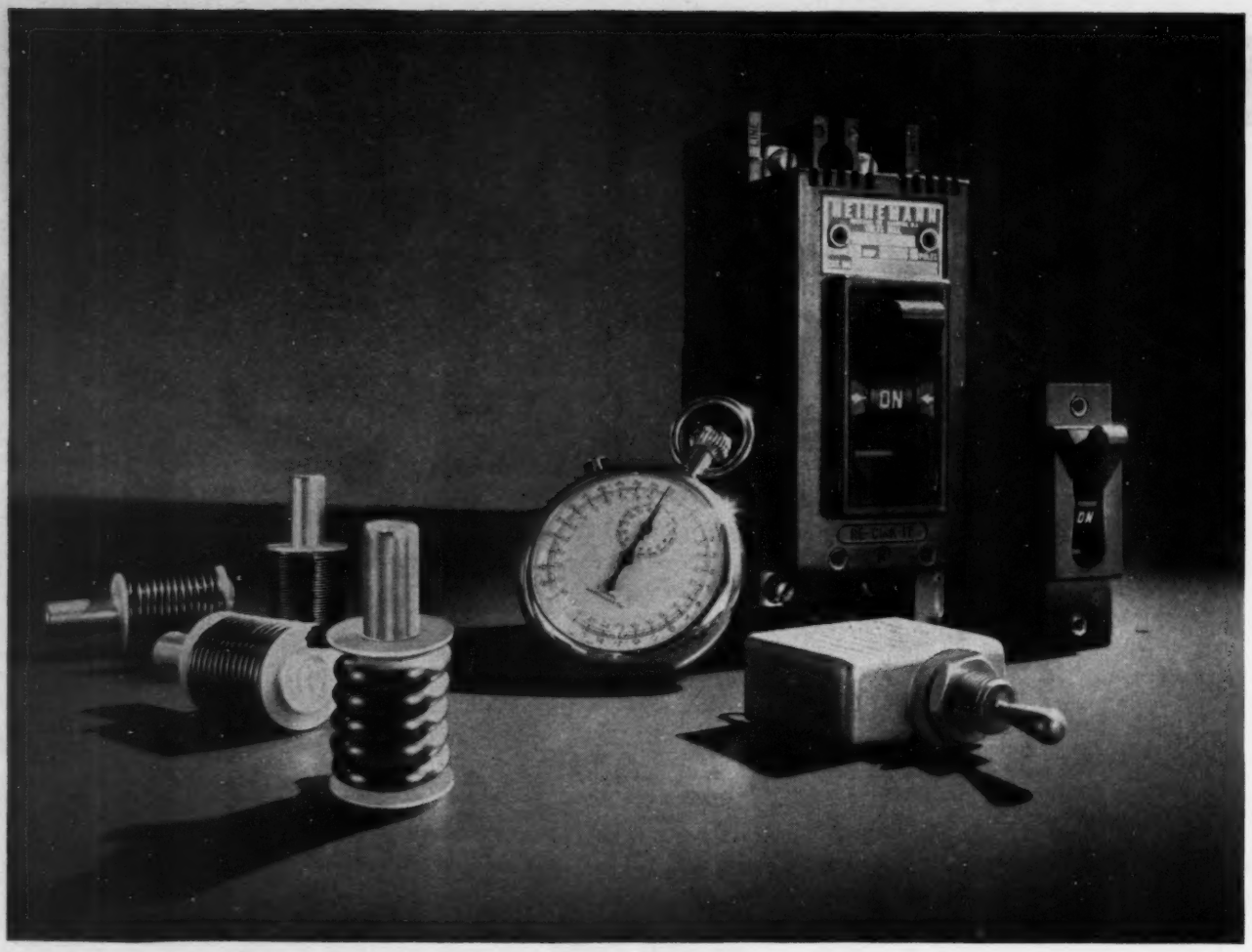

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Precise current ratings, odd or fractional. The number of wire turns of the breaker overload coil determines the current rating. We can wind any one you want between 0.010 and 100 amps (200 on one model) —even way-out ratings like 4.5 or 17.8 or 73 amps.

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Diversity of models. We have them from sub-miniature size on up. Most are available in single-, two- and three-pole constructions, and most can be furnished with a variety of mounting arrangements and terminal hardware styles. Special environmental treatments available, too.

No other overcurrent-protection device quite equals the Heinemann circuit breaker in adaptability to specialized, close-tolerance protective functions. If you'd like to see for yourself, send for a copy of the Circuit Breaker Engineering Guide, Bulletin 201.

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CIRCLE NO. 2 ON INQUIRY CARD

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components & systems DESIGN

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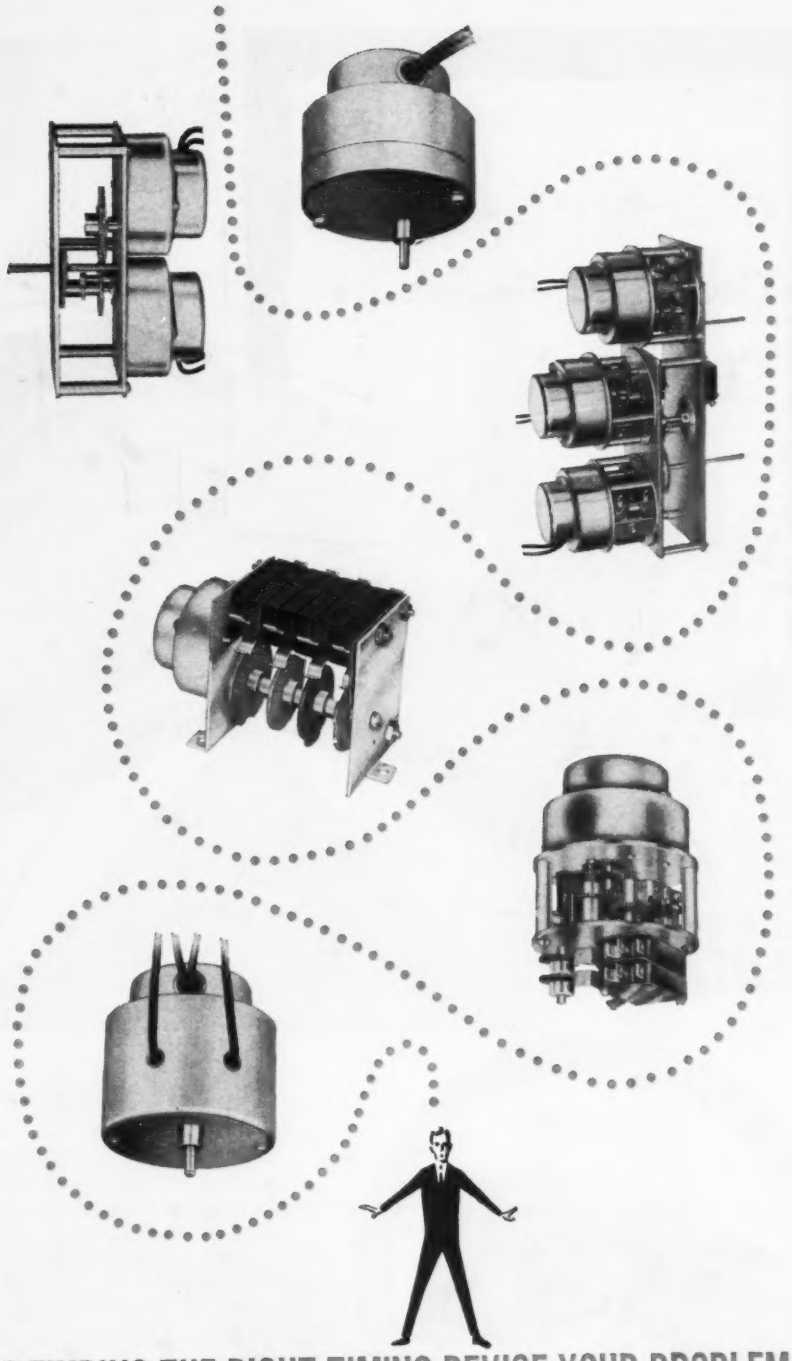

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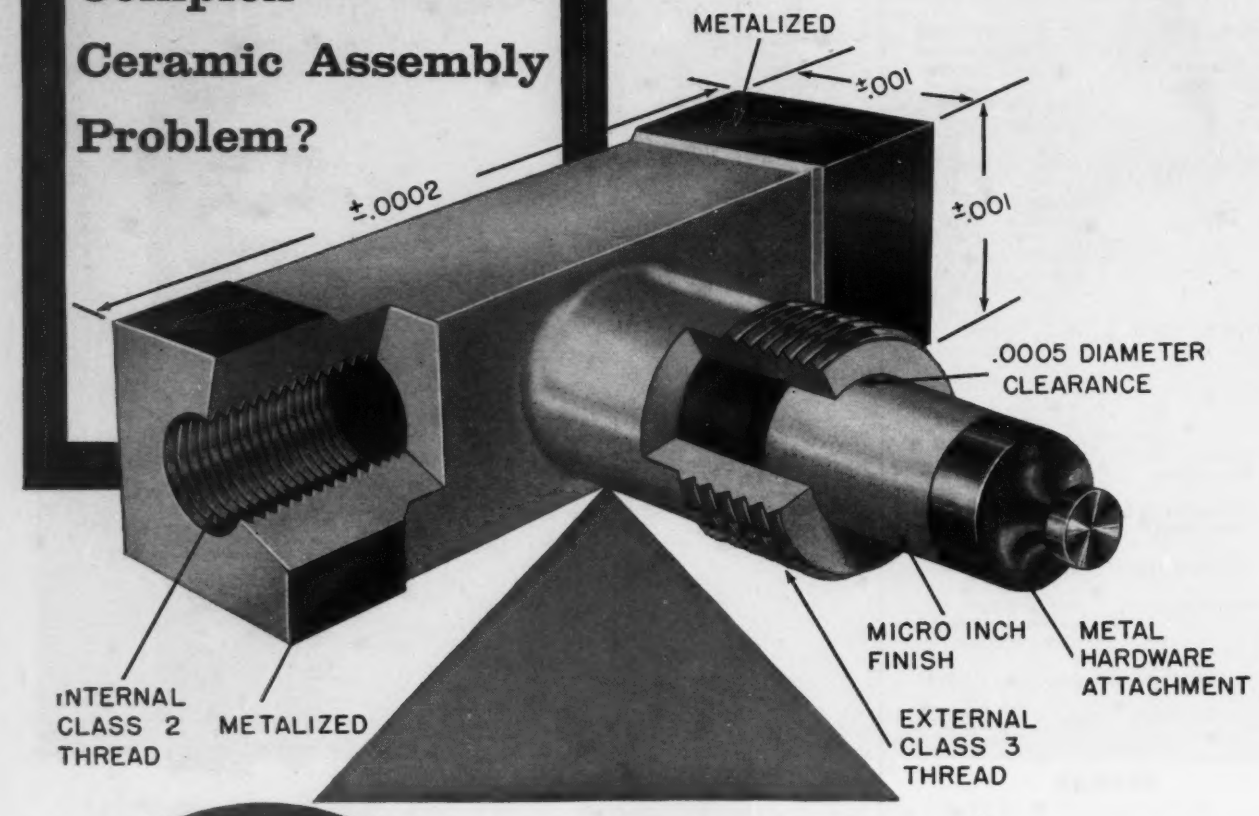
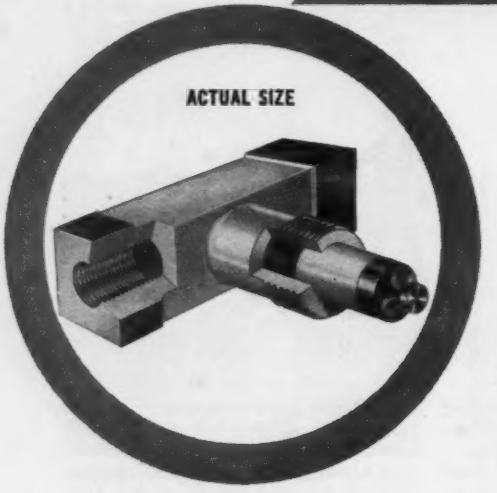
CIRCLE NO. 3 ON INQUIRY CARD

Complex Ceramic Assembly Problem?





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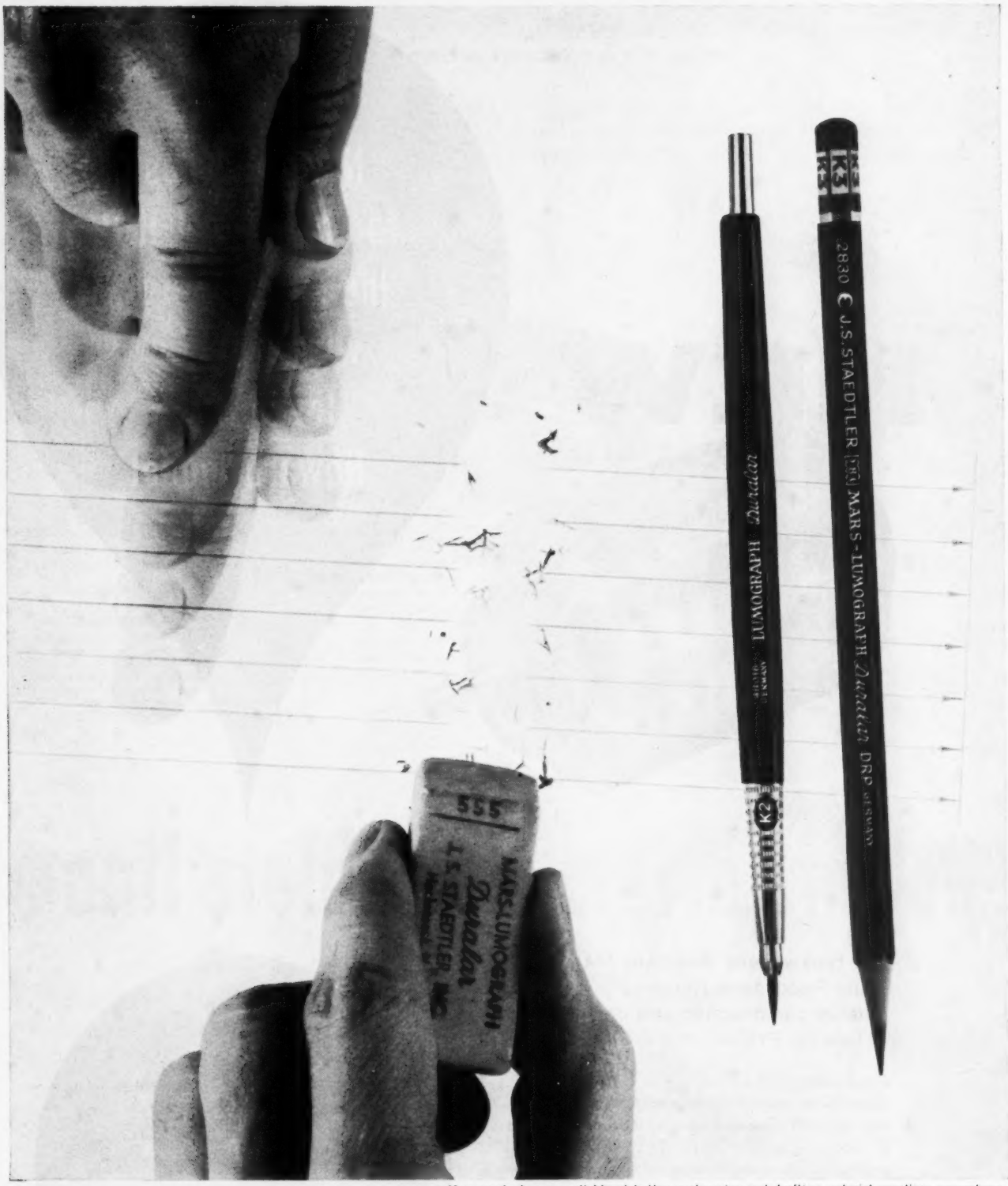

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NEW

Now! Pay less for fractional H.P. Induction motors with this new lower cost Howard model

Howard offers a complete line of

For typewriters, Business Machines, Tape Recorders, Record Players, Appliances... Quality construction and performance at Lowest Prices!

4 pole ratings from 15 milli-h.p. to 1/20 h.p. • Available in hysteresis synchronous, permanent split capacitor, split phase and capacitor start models • 3" diameter • Single or double shaft • Mounting and performance characteristics designed to your requirements • Sturdiest frame in the small motor field

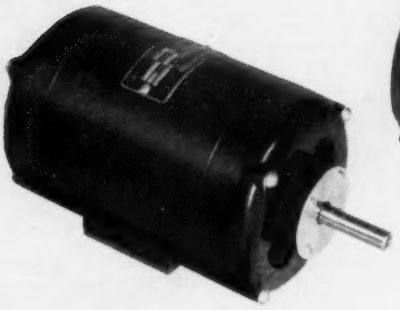
Howard now has the privilege of offering this powerful new top quality induction motor at almost shaded pole prices—an opportunity affording tremendous economies for manufacturers of a wide range of products. If you have an induction application in the works or a project in mind, send us your specifications and we'll rush you a sample. Check its construction and performance . . . then note the price. This is an extraordinary value, demanding your attention. Contact us today.

POWERED BY HOWARD ®

Write for samples and prices on this new cost-cutting induction motor

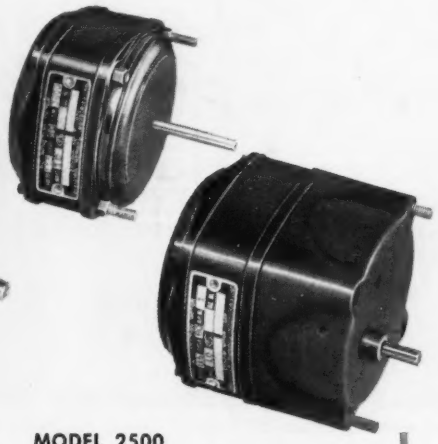
RATINGS FROM 1/1400 TO 1/4 H.P.

Shown below is a representative selection of the Howard induction line. A wide range of standard motors and variations in synchronous, non-synchronous, hysteresis, torque and servo types is available for quick delivery. Send us details of your application—check with Howard before you specify.



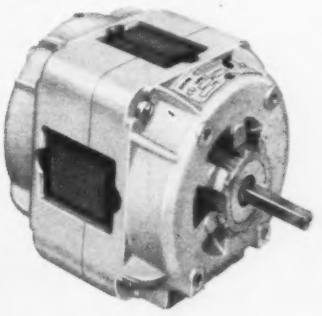
MODEL 2900

TYPE: 2 Pole, 4 Pole, 6 Pole or 8 Pole Induction.
DIAMETER: 3-5/16".
LENGTH: 4-25/32" to 5-21/32" ball bearing.
5-5/16" to 6-3/16" sleeve bearing.
H.P.: *1/70 to 1/15.
FULL LOAD TORQUE OZ. IN.: *10.0 to 30.
BEARINGS: Bronze sleeve type with oil reservoirs, or permanently lubricated sealed and shielded ball bearings.
*Dependent on type of motor used: i.e. Non-Synchronous Capacitor Motors, Standard synchronous, Motors, Hysteresis Synchronous Motors. Torque Motors.



MODEL 2500

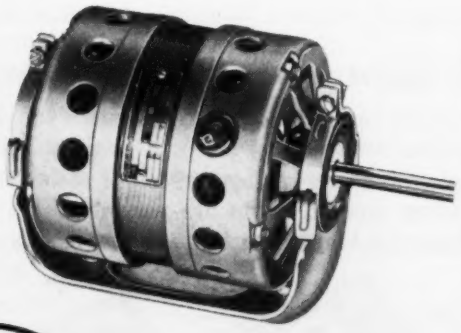
TYPE: 2 pole or 4 pole induction.
DIAMETER: 2-9/16" square.
LENGTH: 1-7/8" to 2-3/8".
SPEED: *1200 to 3600 R.P.M.
H.P.: 1/300 to 1/1400.
MAXIMUM TORQUE OZ. IN.: *1.6 to 3.5.
BEARINGS: *Ball or sleeve.
*Dependent on type of motor used, i.e. Non-Synchronous Capacitor Motors, Torque Motors, Standard Synchronous Motors, Hysteresis Synchronous Motors.



MODEL 9200

TYPE: Induction, torque, synchronous 2, 4, 6 or 8 poles, 25 to 60 cy single (capacitor) two or 3 phase.
H.P.: 1/250 to 1/50 continuous or intermittent duty.
R.P.M.: 900 to 3600.
DIMENSIONS: 2-7/8" x 2-7/8" by 4-1/32" to 4-13/32".
MOUNTING: Pad, resilient ring, face extended bolts.
BEARINGS: Porous bronze sleeve, (ball bearings available at request).

fractional H.P. Induction Motors



MODEL 3700

TYPE: 2 Pole, 4 Pole, 6 Pole or 8 Pole Induction.
DIAMETER: 3-7/8".
LENGTH: 5-1/16" to 5-11/16".
H.P.: *1/25 to 1/7.
STARTING TORQUE: *13 oz. in. to 30 oz. in.
BEARINGS: Porous bronze type with oil reservoir.
*Dependent on type of motor used; i.e. Normal Induction Motor, Hysteresis Synchronous Motor.

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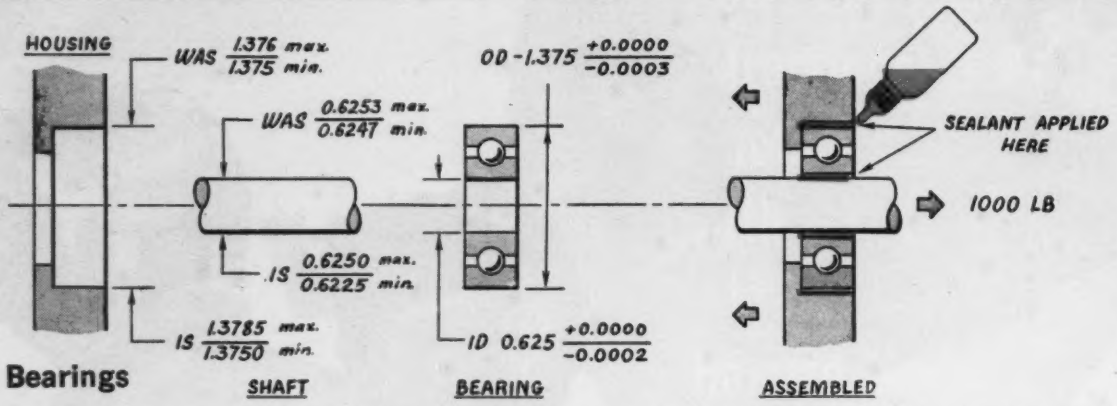
CIRCLE NO. 7 ON INQUIRY CARD

SIMPLIFY ASSEMBLY...
Retain parts on shafts with slip fit and Loctite

Designing with liquid LOCTITE eliminates press fits, shrink fits, broaching, knurling, keyways, set screws and pinning ... provides easier tolerances ... cuts rejects and rework.

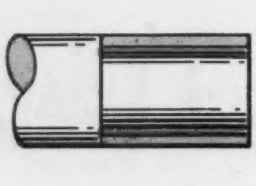


Bearings

LOCTITE Sealant replaced press fit, opening up tolerances .002 inch on shaft and housing. Rejects were cut from 8% to 1% and rework from 20% to 0! Bond to inner race withstands 1000 lbs. thrust ... equal to the best press fit. Slip fit with LOCTITE gives more uniform retention ... eliminates fretting damage due to loose "press fit" or bearing distortion resulting from tight press fit ... assures better shaft alignment. Easier tolerances speed assembly.

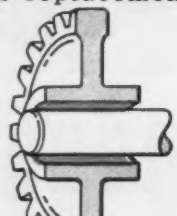
Hardened Sleeves

Eliminates shrink fit ... mounts hardened sleeve without pulling temper.



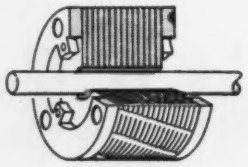
Gears and Pulleys

Eliminates broaching, knurling, shaft distortion. Easier gear replacement.



Rotors

Eliminates shaft distortion and resulting regrinding & straightening.



Fans

Eliminates set screws ... no amount of vibration will loosen part.

LOCTITE Sealant is easy to apply... simple to automate

LOCTITE is a one-component liquid with the unique property of converting to a tough plastic when confined between close fitting metal parts. It does not air dry. It does not require mixing with a catalyst and will not spoil on standing in a storage vessel. It comes fully prepared ... stores for years ... hardens only when treated parts are assembled. It forms a tough seal that resists heat, oil, water, all common solvents. Parts treated with LOCTITE can be disassembled by ordinary methods.

LOCTITE Kit No. 10-10

Contains 10 grades of Loctite Sealant specially put up to assist designers in determining proper grade and use of Loctite in product development and for general experimental work. By selection of proper grade, the designer can apply a predetermined amount of locking torque.

Write for literature and free sample capsule.

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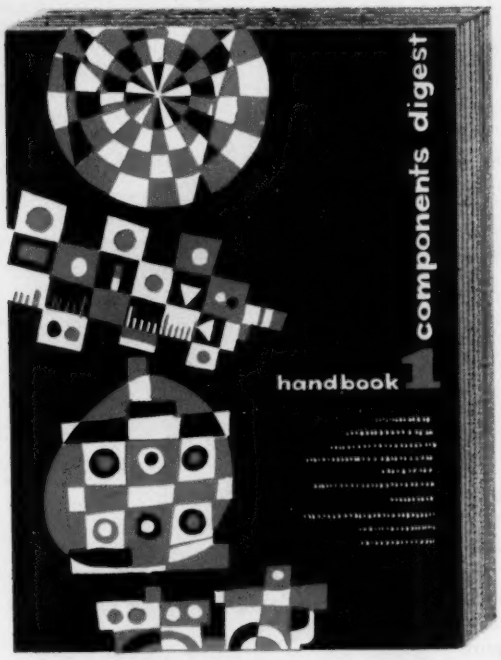

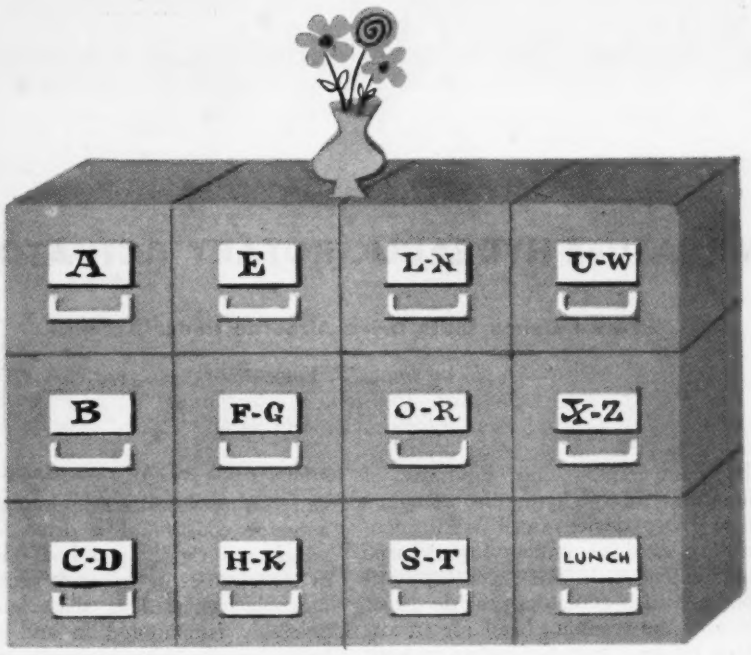

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18 months ago the magazine – ELECTROMECHANICAL DESIGN – initiated a series of studies of important electromechanical components in use today. The series, titled "Components Digest," has been a widely acclaimed feature of the magazine ever since.

Now, nine of these exhaustively researched studies have been collected and published as COMPONENTS DIGEST HANDBOOK No. 1.

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Descriptions of types, sizes and measurements
Construction Information • Design Applications
Selection Factors • Performance Characteristics
Military Specifications
Reliability Assessments
Nomenclature and Definition Tables.

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MINIATURE HYDRAULIC ROTARY ACTUATOR

Two 4-Ounce Units Drive Airborne Radar Antenna

by James F. Fawcett
Air Arm Division, Westinghouse
Electric Corporation

The compactness and lightness of miniature rotary hydraulic actuators make these devices well worth considering as drive motors for airborne radar antennas. In one recent application, two such actuators provide direct drive of the scanning head for an airborne infrared tracking system in both azimuth and elevation. Had electric motors been used, one would be required for each of the two axes of movement with each motor weighing 1½ pounds and measuring about 1¾ inches in diameter and 3⅜ inches in length. The dual-vane actuators used are 0.66-inch thick, 1.25 inches in diameter, and weigh only 4 ounces each.

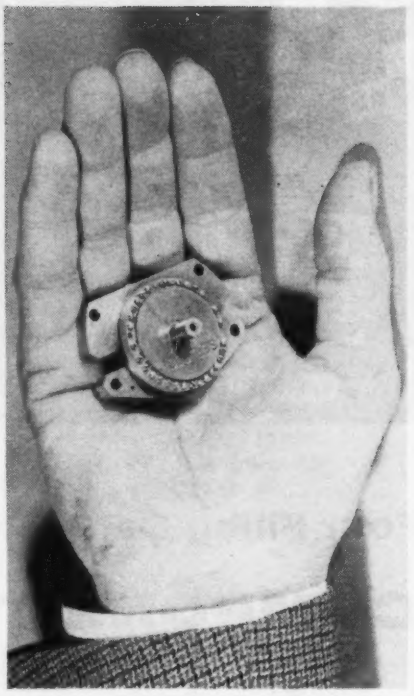

Fig. 2 Westinghouse Miniature Hydraulic Rotary Actuator.

SIMPLIFIED ROTARY ACTUATOR

In its simplest form, a hydraulic rotary actuator consists of a drive shaft to which are rigidly attached one, two, or more vanes or "paddles" called the movable vanes. This shaft and vane assembly is mounted in and encased by a housing with hydraulic pressure seals, shaft bearings, fluid porting, and an equal number of rigidly attached vanes installed internally, called the stationary vanes. The movable vanes are equally spaced, in line, around the periphery of the drive shaft; the stationary vanes are equally spaced, in line, around the bore of the housing.

When hydraulic fluid is supplied to the ports, controlled conditions of pressure, quantity, and time duration produce a controlled rotary oscillation of the drive shaft. Thus, the actuator is a power unit that can be an integrated portion of a servo system.

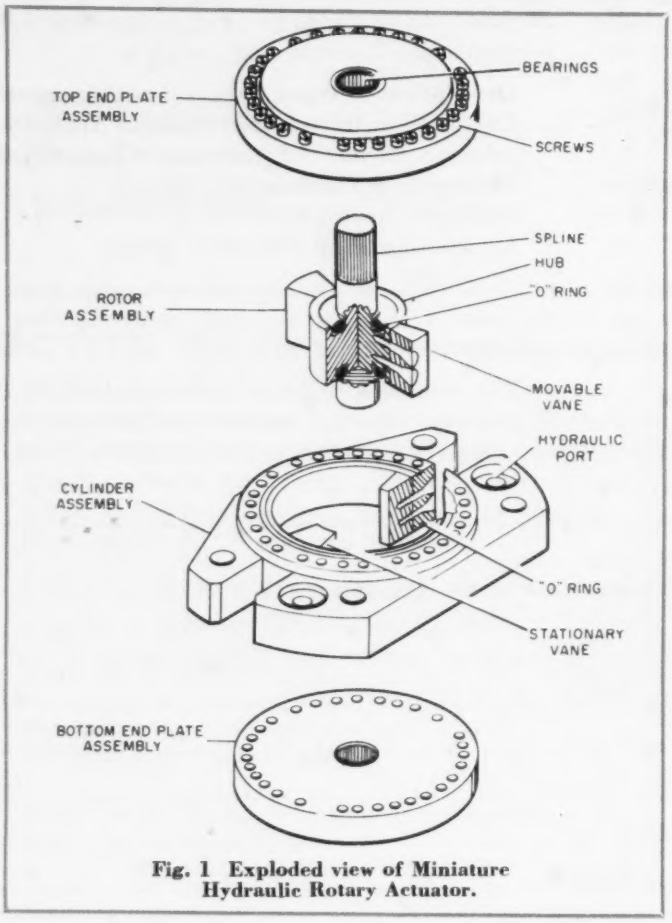

Fig. 1 Exploded view of Miniature Hydraulic Rotary Actuator.

DESIGNING THE ROTOR ASSEMBLY

Starting with a known value for the stall torque that is to be developed by the actuator, the rotor shaft is first sized so that it is capable of transmitting this torque. The two bearing assemblies for the shaft and the shaft load-coupling or shaft end should be sized at the same time so as to make them compatible with the shaft. A spline was chosen as the shaft end because of its suitability for coupling a load to a small shaft.

The two radial-thrust bearing assemblies for the shaft are designed as precision needle bearings having a nitrided surface on the shaft as their inner race, a nitrided bore in each end plate as their outer race, and needle rollers as the bearings. For each bearing assembly the shaft, bore, and individual needle rollers are measured and selectively fitted so that the radial

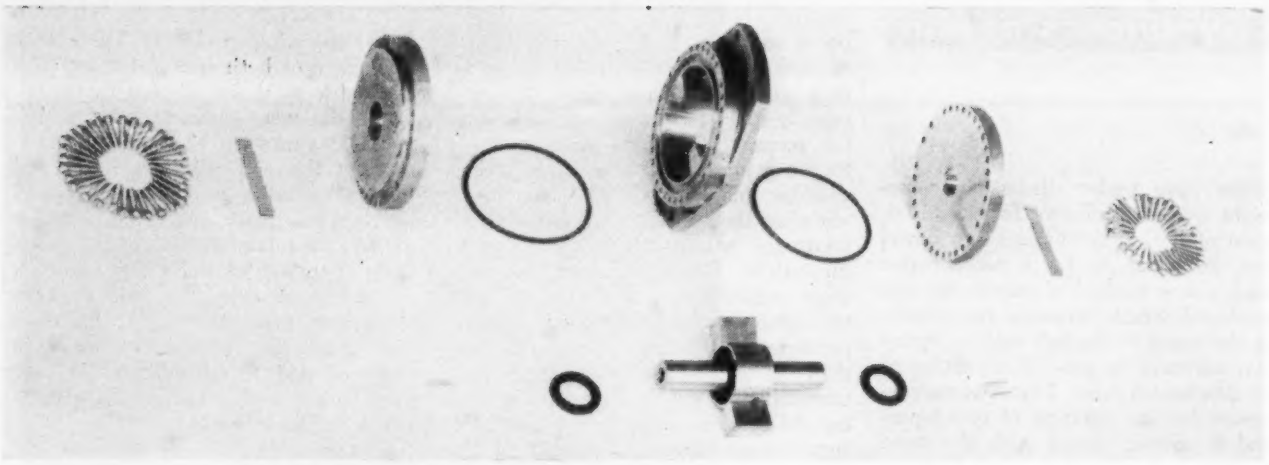

Fig. 3 Parts of the miniature rotary hydraulic actuator shown separately.

play of the rotor is 0.0001 to 0.0002 inch. The longitudinal thrust on the rotor is reached out by the faces of the movable vanes bearing on the inner surfaces of the end plates.

A hub, integral with the shaft, is located between the shaft bearing assemblies and machined to accommodate moving O-rings along both radial faces. These two O-rings form the shaft seal allowing the rotor to rotate with relation to the actuator housing without permitting external fluid leakage. The hub height is sized in conjunction with the height of the movable vanes and must be large enough to accommodate the movable vane attachment screws as well as the two grooves for the shaft O-rings.

Next, the movable vanes are sized and permanently attached to the hub to complete the rotor assembly. The number of movable vanes to be used is governed by the maximum angular rotation required of the actuator. Since past experience has shown an angular vane width of 25 degrees to be a good all-round value for both movable and stationary vanes if an angular range of up to ±155 degrees is required, one movable vane should be used; if up to ±65 degrees, two movable vanes; if up to ±35 degrees, three movable vanes, and so forth. Since the torque output of the actuator is proportional to the number of movable vanes for a given face size of the movable vane, the number of movable vanes should be increased to the maximum allowable number so as to make the actuator as small as possible.

To this point, no mention has been made of the maximum fluid pressure available for driving the actuator. However, before we can size the movable vanes, the maximum pressure differential that is capable of being developed between the two faces of each movable vane must be fixed. For this design step, we base our calculations on this relationship: stall torque of an actuator is equal to the product of movable vane maximum pressure differential multiplied by the number of movable vanes, multiplied by the one-face area of a movable vane (or vane-height times vane-length), multiplied by the mean radius arm of a movable vane. Written symbolically the relationship is

$$T = P \times N \times H \times L \times R = P \times \text{displacement factor},$$

all in compatible units.

The subject of sizing the movable vane face area, that is, determining the optimum relation between vane-height and vane-length, is beyond the scope of this discussion. Some of the influencing factors are the external actuator configuration that is desired, control of internal fluid leakage, frequency of response of actuator, mechanical strength of vanes, and mechanical strength of vane attachment to rotor hub.

Normally each movable vane is rigidly attached to the rotor hub by one or more screws and doweled in place by two or more dowel pins, but

TABLE A

Characteristics of Miniature Rotary Actuator for Scanning Head of Airborne Radar Antenna

1. Type of actuator	Hydraulic rotary actuator
2. Number of vanes	Two movable vanes, two stationary vanes
3. Angular rotation	±65 degrees maximum from a center position
4. Operating pressure	1000 psig
5. Stall torque at 1000 psig	41 inch-pounds
6. Displacement factor	0.041 cubic inches per radian
7. Breakaway friction	1 inch-pound torque or less with 500 psig oil pressure (Mil-0-5606 oil) applied to both sides of the vanes
8. Internal fluid leakage using Mil-0-5606 oil at 80 F	0.001 cubic inches per second for fluid pressure of 495 psig on low pressure side of valves and fluid pressure 505 psig on high pressure side with movable vanes centered angularly between the stationary vanes. This implies a leakage factor of 0.0001 cubic inches per second-pound under 500 psig quiescent conditions.
9. Basic size	1-1/4 inch O.D. by 0.66-inch thick (shaft end and mounting flange extend outside this envelope)
10. Output shaft	27-tooth, 128/256 diametral pitch, 45 degrees pressure angle, external involute serration hobbed on the end of the shaft for a perfect tooth length of 0.233 inch.
11. Hydraulic ports	0.055-inch I.D.
12. Method of mounting	External flanges
13. Weight	4 ounces

in the case under discussion, vane-height was not sufficient for the installation of both a screw and two dowel pins. In order to keep the actuator small, a new method of attachment was developed which consisted of cementing the vanes to the hub with an epoxy resin adhesive to provide a portion of the attachment joint. This was supplemented by the insertion of two taper-headed screws, coated with the same adhesive and torqued in place to complete the joint. When the epoxy resin adhesive cured, these screws fulfilled the requirements of both dowel pins and attachment screws. Cross porting is machined through the center of the shaft for fluid in multiple movable vane designs (none is required in single movable vane designs) and the rotor is finished-machined to complete the rotor assembly.

HOUSING ASSEMBLY DESIGN

The housing assembly is made up of three subassemblies; namely (1) the top end-plate assembly, (2) the cylinder assembly, and (3) the bottom end-plate assembly. Except for minor differences, the top end-plate and bottom end-plate assemblies are identical.

The internal diameter and height of the cylinder are known values at this stage of the design, having been fixed in both cases by the design values selected for the design of the rotor assembly. Internal diameter is equal to rotor hub diameter plus twice the length of a movable vane plus the radial clearances; cylinder height is equal to movable vane height plus longitudinal clearances. Next, both faces of the cylinder are machined to accommodate static O-rings just outboard of and concentric with the bore of the cylinder. Since these are static fluid-pressure seals, the substandard cross-sectional diameter O-rings are used in order to conserve radial space. The stationary vanes, being of the same general design as the movable vanes, are attached to the inside wall of the cylinder using the epoxy resin adhesive —two taper-headed screw design previously described for the movable vanes. Since the stationary vane screws are installed through the wall of the cylinder from the outside, thereby breaking the fluid pressure seal of the actuator, the epoxy resin adhesive in the stationary vane case serves the added purpose of a fluid pressure seal.

Tapped holes are next machined through both faces of the cylinder on a minimum bolt circle, outboard of and concentric with the static O-ring grooves. Although six to eight equally-spaced screws are adequate for securing each end-plate assembly to the cylinder, the number of screws can be increased to thirty or more, allowing their size to be reduced accordingly while still maintaining an equivalent holding power, to conserve radial space. Since the cylinder wall thickness required from a radial pressure standpoint is invariably less than the wall thickness required to accommodate the O-ring groove and tapped hole combination, the above design considerations then dictate the minimum outside diameter of the cylinder.

Several variations are available for mounting the actuator and porting fluid to and from it. Both functions can be accomplished by utilizing either of the end plates, the cylinder, or any combination of the three, although in the case of mounting the actuator, it is highly recommended that this function be done from the cylinder only. Normally, fluid is ported to and from the pressure chambers of the actuator via two radial ports through the cylinder wall, astraddle one of the stationary vanes, breaking through to the cylinder bore adjacent to the base of the vane. This standard porting blends quite well with a cylindrical, integral flange-mounted unit since the flange can be designed to serve the dual purpose of mounting, and of terminating the porting to and from the actuator with a fluid pressure seal; namely O-rings.

Each end-plate assembly serves three main functions; namely (1) forms a part of the fluid pressure seal both for external leakage and internal leakage, (2) forms the outer race for the shaft bearings and maintains same in correct location, and (3) forms the surface upon which the movable vanes can react out longitudinal thrust encountered by the actuator rotor. The outside diameter of the end-plate and its minimum height or thickness at its bearing bore are known values at this stage of the design, having been fixed in both cases by previous design decisions; namely the outside diameter of the cylinder and the length of the shaft bearing rollers.

The thickness of the end plate (other than the shaft bearing area) is now determined from fluid pressure-strength considerations and maintained at such a value that end-plate deflection at the bearing bore does not exceed one 0.000,001 inch in relation to the end plate at the bolt circle at the maximum fluid operating pressure. The entire inner face of both end plates are electrolized to minimize friction and to improve the wear characteristics of the movable vanes on the end plate.

After the end plates are attached to the cylinder, with the rotor and bearings in place, and the actuator aligned for minimum friction (an elaborate operation in itself) they are then accurately doweled to the cylinder using two small taper pins for each end plate. Taper pins are used in place of standard dowel pins to ease manufacturing difficulties and also to retain miniaturization.

The bearing retainer washers are staked in place in the end plates, locking the bearings in place, and thereby completing the actuator. With the O-ring seals in place and the shaft bearings lubricated, the actuator is ready for testing and use.

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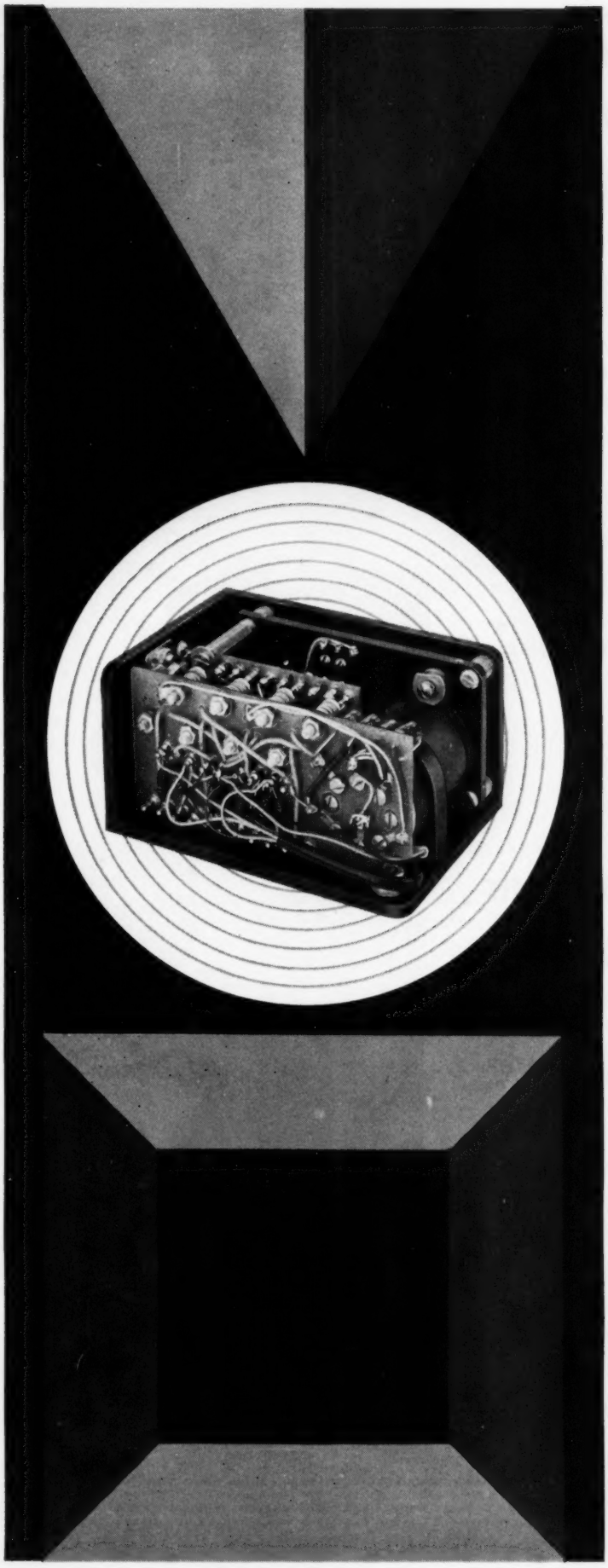

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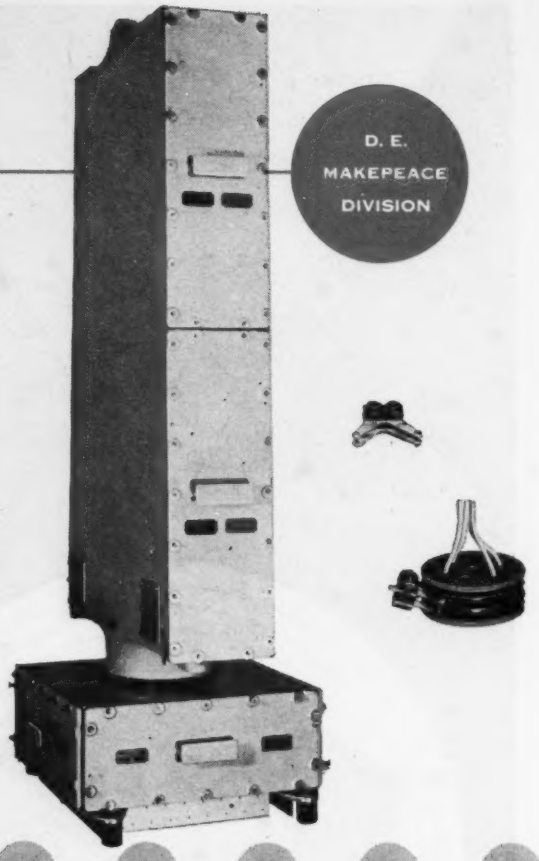

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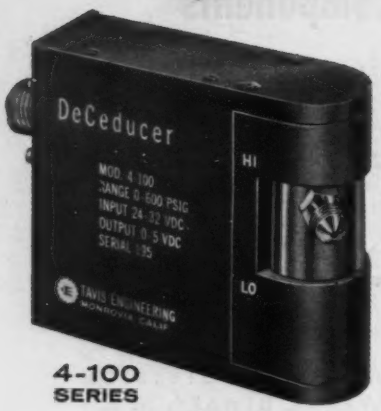

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NEW SYNCHROS AND RESOLVERS

Solid State Trigonometric Function Generators and Electrical Two-Speed Synchro Systems

The March 1960 Synchro Design and Testing Symposium in Washington, D. C., sponsored by the Navy Department Bureau of Naval Weapons, revealed two significant developments.

Drs. L. J. Brady and M. A. Melehy of Kearfott Division, General Precision Inc., Little Falls, N.J., reported a very promising application of the Hall effect to the development of prototype solid state synchros and resolvers. The magnitude of the Hall effect voltages that can now be achieved for use in trigonometric function generation could ultimately lead to the development of solid-state servomechanisms.

L. Kahn of Eclipse-Pioneer Division, Bendix Aviation Corp., Teterboro, N.J., described the successful development of an electrical synchro, that effectively replaces two-speed systems and is twice as accurate.

SOLID STATE FUNCTION GENERATORS

If a charged particle moving in a vacuum is exposed to a transverse magnetic field, the particle experiences a force that alters its path. The direction of the force is perpendicular to both direction of motion of the particle and of the magnetic field. This effect is illustrated in Fig. 1.

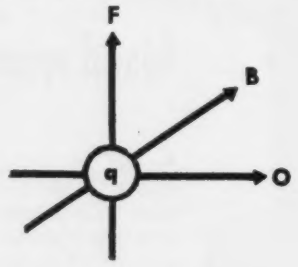

Fig. 1. Diagram showing Force (F) acting on a charged particle resulting from a magnetic Field B.

The force is given vectorially by the expression

$$\bar{F} = q\bar{v} \times \bar{B}$$

where F is the force in Newtons, q is the charge on the particle in Coulombs, v is the velocity of the particle in meters/sec and B is the magnetic field flux density in webers/meter^2. As the velocity increases, the force becomes larger. This well known effect is used in numerous applications such as scanning electron beams in cathode ray and television tubes, mass spectrographs, cyclotrons, betatrons, traveling wave tubes and the like.

A comparable effect takes place when a current flows through a solid in the presence of a magnetic field. The charge carriers acted upon by a force similar to that shown in Fig. 1 are deflected, resulting in a measurable electric field. This is the principle of the Hall effect. To obtain an appreciable Hall voltage for a given magnetic field intensity, the charged carriers in the solid must move as rapidly as possible. Mobility of the carriers, defined as the ratio of the velocity of the carriers to the electric field intensity, provides a standard of comparison for the magnitude of the Hall effect in different solids of the same dimensions and the same field conditions. The equation for the Hall voltage across the crystal in Fig. 2 is

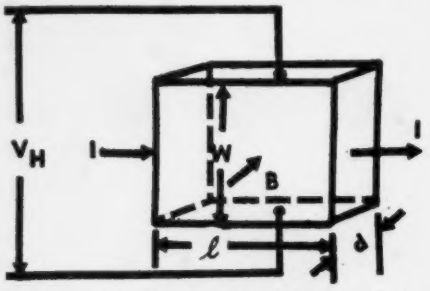

Fig. 2. Sketch of a Hall device. I is control current, B is magnetic flux density and V_H is Hall voltage.

$$V_H = 1.18B\,(pw/ld)^{1/2} \times (\mu/qn)^{1/2}$$

Where

V_H = the Hall voltage across the crystal
P = the maximum allowable power to be dissipated in the crystal
B = the magnetic flux density in webers/m^2
μ = the mobility in m^2/volt sec
q = the magnitude of the electron charge = 1.602 x 10-19 coulombs
n = the density of current carriers per m^3

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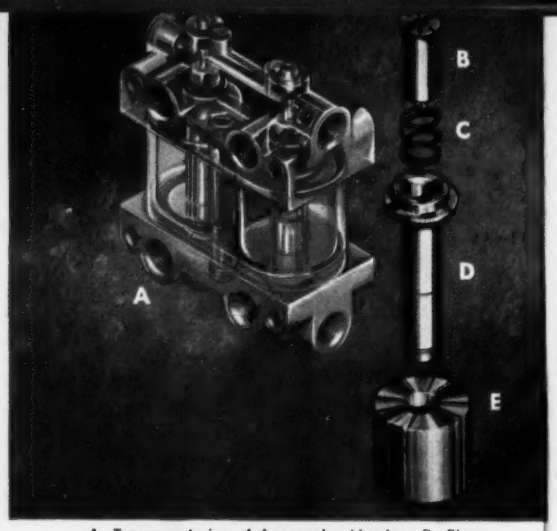
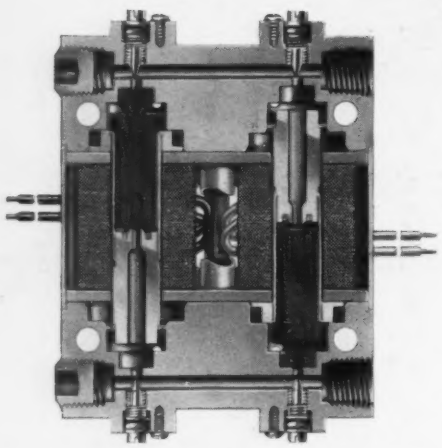


A. Transparent view of 4-way solenoid valve B. Plunger
C. Plunger return spring D. Sleeve E. Coil

SKINNER four-way solenoid valves available in three basic types



The Skinner V9 solenoid valve is two 3-way valves in one compact housing. Both valves may be independently controlled and metered to provide accurate, dependable control of single- or double-acting cylinders, or larger pilot-operated valves.

V9 types are available without adjustable flow and with metering at both exhaust ports, both inlet ports or full metering of all ports.

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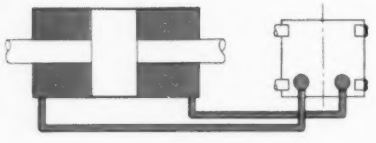
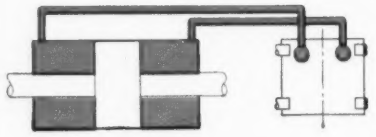
Maximum Operating Pressure Differential—0 to 150 PSI (up to 225 PSI also available)
Temperature Range—minus 40°F. to plus 180°F.
C_V Factor—$\frac{3}{64}$" .052, $\frac{1}{16}$" .095, $\frac{3}{32}$" .156, $\frac{1}{8}$" .214
Mounting—$\frac{1}{4}$" through-bolt holes.

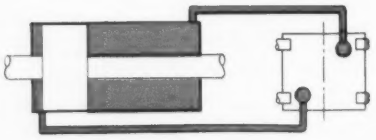
Normally closed—normally closed V933 valves with a neutral position. Generally applied on double-acting cylinders where the piston is in a neutral position without pressure when both coils are de-energized. This permits manual shifting of the piston without operating the valve.



Normally open—normally open V955 valves with a neutral position. Generally applied on double-acting cylinders where both sides of the piston are to be open to pressure when both coils are de-energized. Under certain conditions, the first operating stroke of double-acting cylinders will be smoother with this valve in use.



Normally closed—normally open V935 valves with no neutral position. Generally applied on double-acting cylinders where the piston is to be in retracted or extended position with pressure when both coils are de-energized. Wiring is simple—both coils are operated simultaneously and can be controlled by one single-pole, single-throw switch.



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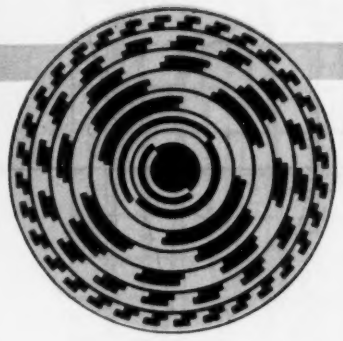

New Norden "disc" design creates

High count, multiple turn Gray encoders ...without indexing mechanisms

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- assure freedom from error due to positional ambiguities.
- are the smallest multi-turn Gray encoders available, and store nearly twice as much in a given diameter as units using a pure binary code.
- eliminate ambiguity situations caused by cross-coupling, simplifying telemetering problems such as may arise in space satellites.

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ADC-16-GRAY	65536	64	3.25
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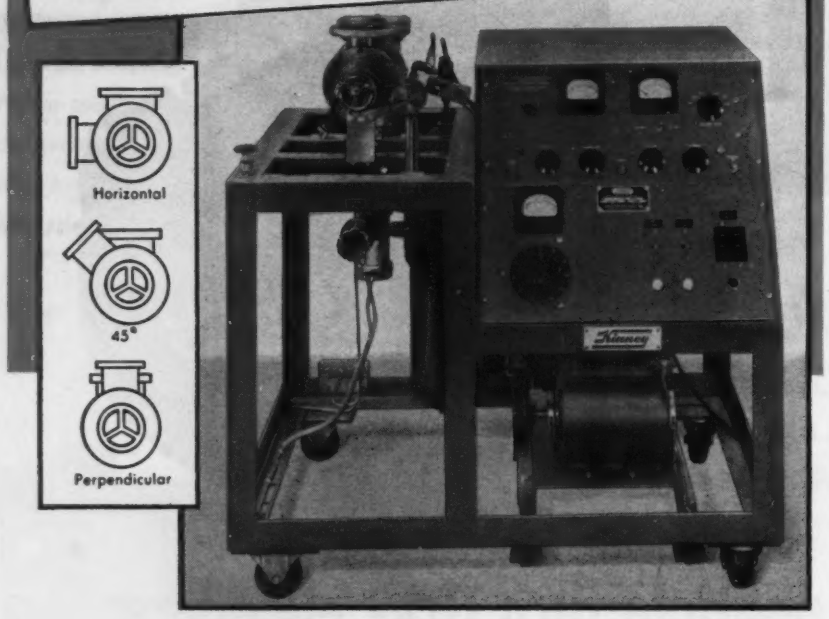

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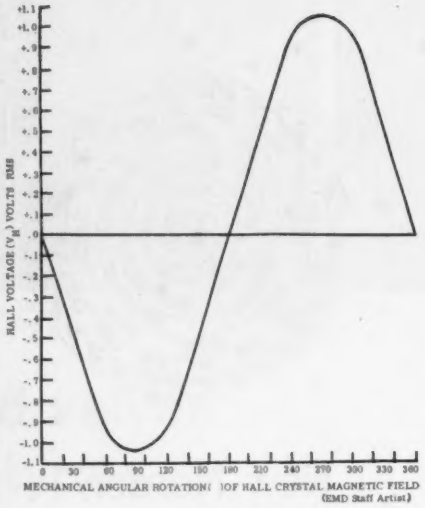


Fig. 3. Output of Hall generator proportional to sin.

w, l, d = the dimensions shown in Fig. 2 measured in meters

The equation shows that use of thin films increases the Hall effect, since Hall voltage increases inversely as the square root of the thickness d.

The Hall voltage across the device in Fig. 2 may also be expressed as

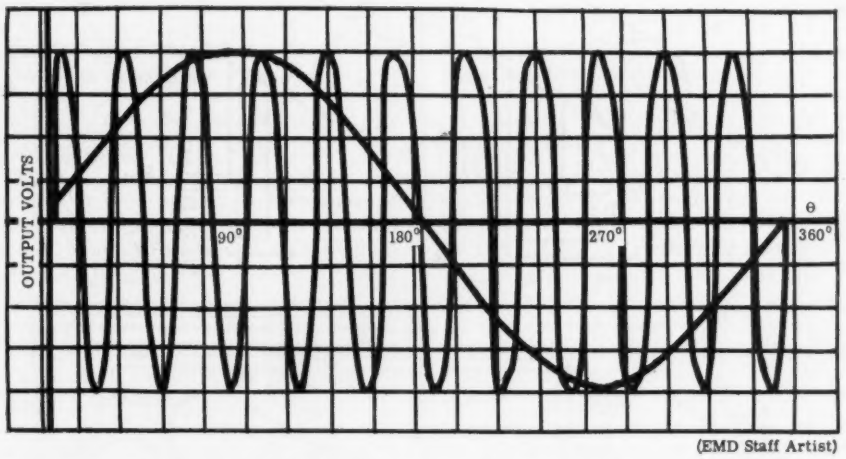
$$V_H = KIB \cos \theta$$

where θ is the angle between I and B. This equation suggests the application of the Hall effect to generation of trigonometric functions. A simple trigonometic function to provide angle measurements can be generated by keeping B and I constant and varying θ. Investigating this area, Kearfott has obtained test results of Hall voltage vs angular rotation as shown in Fig. 3. Functional errors of the device were reported to be too small to measure with standard testing apparatus.

In addition to these simple functions, Hall devices may be used for the generation of relatively complex trigonometric functions. For example, by placing two Hall devices parallel or perpendicular to each other in the same field and allowing the output Hall current of one to become the control current of the other, either through simple circuitry or through an amplifier, a voltage of the form k sin θ cos θ, k′ sin^2 θ or k″ cos^2 θ can be generated. Among the many trigonometric functions that may be generated are

$$V_H = k(\cos \theta - \sin \theta)\ (\cos \theta + \sin \theta)$$
$$= k(\cos^2 \theta - \sin^2 \theta)$$
$$= k \cos 2\theta$$

$$V_H = k(\sin^2 \theta + \cos^2 \theta) = k$$
$$V_H = k \sin \theta \cos \theta$$
$$k/2 \sin 2\theta$$



(EMD Staff Artist)

Fig. 4. Output wave shape of the two-pole and multi-pole elements of the Bendix two-speed synchro system.

Brady and Melehy pointed out that such function generators offer very interesting possibilities. For example, it should be possible to switch from one combination of outputs yielding sin θ or cos θ to the functions of double the angles, thus allowing maximum sensitivity under varying conditions. Moreover, it should be possible to switch from cosine or sine outputs to one where $V_H = k(\sin^2\theta + \cos^2\theta) = k$ for use as an error indicator.

Hall devices can be mounted not only at right angles or parallel to each other, but at other angles to yield almost any conceivable trigonometric output. By shaping the magnetic field properly, a variety of outputs can be obtained, such as

$V_H = K\,e^x$
$V_H = k\,e^y$
$V_H \doteq k\,(1 - e^x)$
$V_H = k\,(e^{xy})$

ELECTRICAL TWO-SPEED SYNCHRO SYSTEM

Need for synchros that could result in data transmission system accuracies of one minute or better, and that were insensitive to thermal and mechanical stresses led the Ellipse-Pioneer Division of the Bendix Aviation Corp. to sponsor the development of the electrical two-speed synchro. By a two-speed synchro, they mean a multi-polar synchro with wound rotor and stator whose output has n/2 electrical cycles with one mechanical shaft rotation where n is the number of poles, and a corresponding two pole device. Accuracy is obtained on the multi-pole element through the secondary winding's sensitivity to a part of each of the maximum flux waves, which are distributed around the entire physical structure, thus continually averaging the entire magnetic structure. Although there could be a point to point change, it was assumed that the change in the average magnetic structure would be negligible. The two-pole element is required to prevent ambiguity at the null position of the multi-polar element.

Mr. Kahn reported that the results of the development program were extremely successful. Bendix found that unit accuracies of 30 seconds could be obtained by using production manufacturing tolerances that were previously used on 10 minute synchros and that this error did not change with ambient temperature or with deliberately severe stresses at the lamination stack area of the housing. He also reported that by proper winding design, it was possible to wind the multi-polar and the two-pole elements on the same lamination stacks.

Fig. 4 is a sketch of the output wave shapes of the two-pole and multi-pole element.

Fig. 5 shows the AY996–A1 Electrical Two-Speed Synchro which may be used as either a transmitter or control transformer and has a twenty-two pole

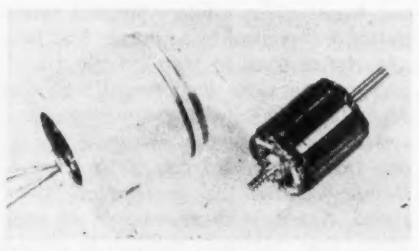


Fig. 5. Bendix' AY996—A1 two-speed synchro.

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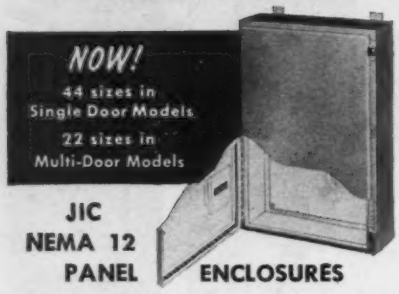

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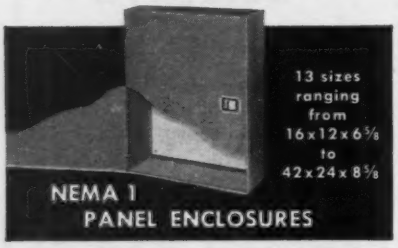

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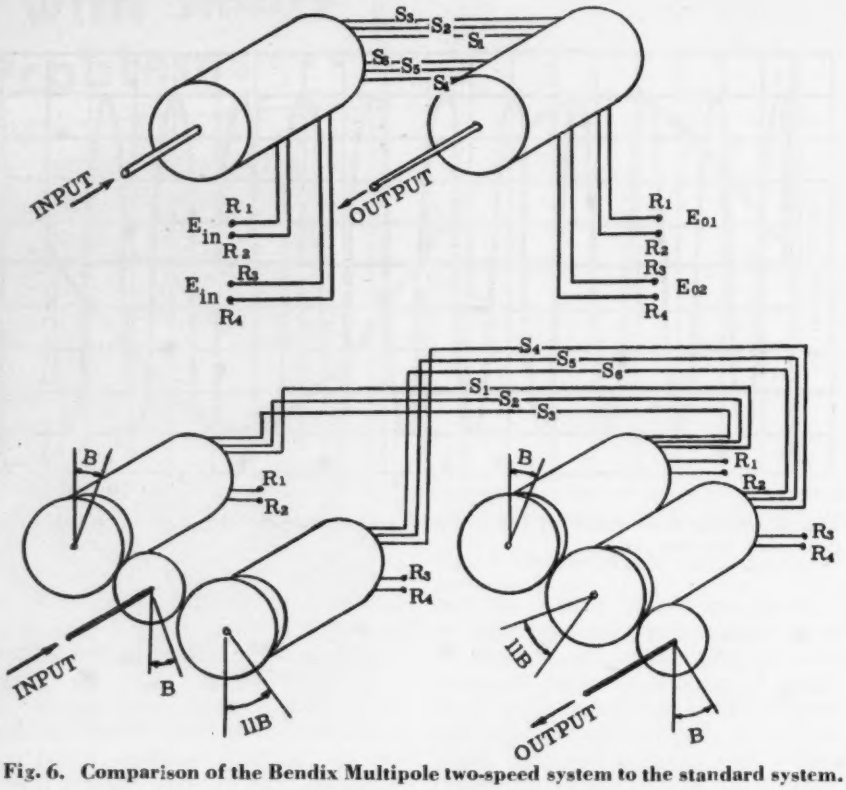

Fig. 6. Comparison of the Bendix Multipole two-speed system to the standard system.

or eleven-cycle multi-speed element.

When 2 electrical two-speed synchros are used back to back for data transmission, the only additional requirement to those for 2 conventional two-pole synchros is a simple diode switching network to provide the correct signal to the servo amplifier. The size of the network is such that it could easily be packaged in the cap of the control transformer. Mechanical alignment and electrical zeroing procedures are identical to those for normal 3-wire synchros. Not only is the static accuracy said to be excellent, but so is the signal to null ratio, which insures that the servo system will have sufficient resolution, compatible with the accuracy characteristics.

To accomplish data transmission with a conventional 2-speed system utilizing 11-to-1 gearing would require a coarse system of transmitter and control transformer, a fine system of transmitter and control transformer, and two gear trains, one to step up the speed and one to slow it down. Using the AY996-A1 electrical two-speed synchro system eliminates the two gear trains, one transmitter and one control transformer. Using the mechanical two-speed system with seven minute synchros, it is extremely difficult to obtain errors better than two minutes due to gearing errors. This error will change as the gears wear, and with ambient temperature changes because of the two-pole synchros.

The electrical two-speed synchro is compatible to pancake construction and is extremely effective in gyro applications Kahn said, since the inherent averaging effect of the multi-poles reduces errors due to gimbal dissymetries.

Fig. 6 is a comparison of the Bendix Multipole two-speed system to the standard system.

In summarizing, Mr. Kahn listed three major advantages of the system:

- Fewer elements. System may consist of a transmitter and control transformer rather than 2 transmitters, 2 control transformers and 2 gear trains.
- Greater reliability with no increase in package outline. The larger unit size permits a more rigid mechanical construction concerning ring assembly, brush assembly, bearings and the use of larger wire sizes.
- Elimination of second harmonic errors due to uneven stresses on the magnetic structure caused by

1. clamping of the unit for mounting purposes.
2. stresses due to differential mechanical expansion and contraction over the temperature range.
3. stresses generated in manufacture.

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THERMOELECTRIC GENERATOR

Small Power Plant Runs For A Year On $10 Worth of Propane

Believed to be the first practical thermoelectric generator to be made commercially available in the United States, a new generator, developed by General Instrument Corp., Newark, N. J., employs thermopiles of semiconductor elements to convert the heat of burning propane into electricity. It produces five watts of power, steadily and continuously, for as long as the fuel supply lasts. On 50 gallons of propane, the unit will run a year.

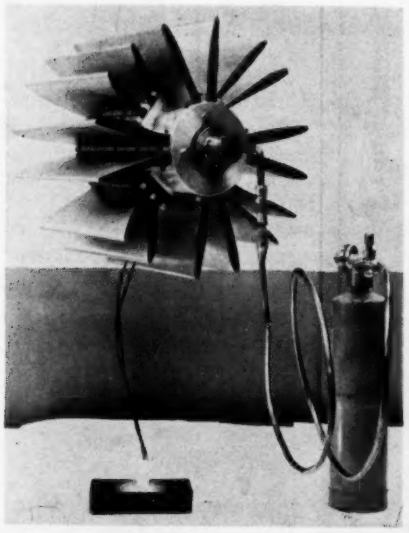

Fig. 1 Propane fuel is fed into the generator where it burns steadily. The heat, captured in a combustion chamber, is converted by thermopiles of semiconductor elements directly into electricity, which lights small lamp.

The 10 lb., 1 ft. high automatic power plant has at its center a specially-designed burner that keeps the propane gas at a constant temperature and uses more than 85% of the heat content of the fuel. A metal combustion chamber, surrounding the burner, captures the heat. Attached to each of the four sides of the combustion chamber are the thermopiles. The heat not used by the thermopiles is conducted directly to heat rejection fins made of aluminum, which form the outer shell of the whole unit and give it a star-like appearance.

Particularly applicable as a highly reliable and un-manned source of power in remote areas, the generator is expected to be priced at $500 or less in large-scale production quantities.

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LIGHT AMPLIFICATION

Thousand-Fold Electron Multiplication

So sensitive that it makes visible a single electron, a tube, the Astracon, operates by a unique amplifying principle discovered 5 years ago at the Westinghouse Research Laboratories, Pittsburgh, Pa. The image of an object, so dim that it is invisible to the naked eye, is focused by lenses onto a light-sensitive screen, called a photosurface, at the input end of the tube. Individual particles of light, or photons, strike the surface and eject electrons from it. Each ejected electron is then accelerated forward by 2000 volts and strikes head-on into a two-layer film, only a few millionths of an inch thick.

Front surface of the film is aluminum and the back surface has a slightly thicker layer of an insulating material. When a high-speed electron crashes into the film, it penetrates into the insulator and releases four or five additional electrons which are accelerated into a second film, or dynode, where the electron multiplication is repeated.

Fig. 1 Astracon makes single electron visible.

Five such steps multiply a single electron into about 3000 and then with a final 20,000 volt-boost are aimed into a thin layer of fluorescent material at the output end of the tube. Here they release 20,000 or more photons of visible light. Thus, if the light striking the input photosurface is in the form of a dim, invisible image, the Astracon exactly reproduces that image on its output thousands of times brighter.

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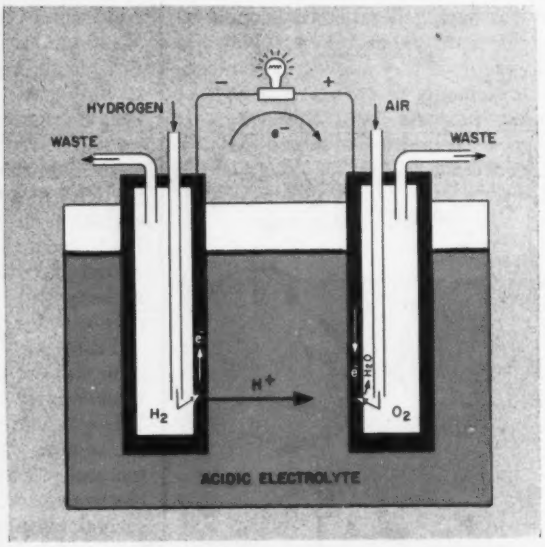

Fig. 1 In a typical fuel cell, with an acid electrolyte, hydrogen reacts at the anode to give up an electron to the load while simultaneously releasing hydrogen ions in the solution. At the cathode, these hydrogen ions combine with oxygen and electrons from the load circuit to form water and complete the circuit.

Representing one of the first practical applications of fuel cells, a portable power supply developed by General Electric is now undergoing evaluation testing. The unit, designed to supply power for portable field radar sets, operates at full load for a minimum of 2000 hours without maintenance. However, a much longer life is expected since experimental fuel cells have been operating continuously for more than a year.

Heart of the unit is an ion-membrane fuel cell. The development of this cell represents a major step toward a fuel cell power source that can be mass produced as an off-the-shelf item, the goal of GE's research program.

TYPICAL HYDROGEN-OXYGEN FUEL CELL

The process of electrolysis is reversed in the hydrogen-oxygen cell, shown in Fig. 1. Instead of separating water into its components by passing an electric current through it, water is created in a controlled reaction which liberates energy in the form of electricity. The concurrent production of water and electricity is not subject to the Carnot limitation. Theoretical efficiency is 83 percent at 25 degrees C, with negligible current flow.

In an acid-type cell, hydrogen (a gas) gives up an electron to the electrode (usually a solid), and ions to the electrolyte (usually a liquid). An illustration of the necessary simultaneous contact is shown in Fig. 2. The system must be so designed that, despite changing loads, the

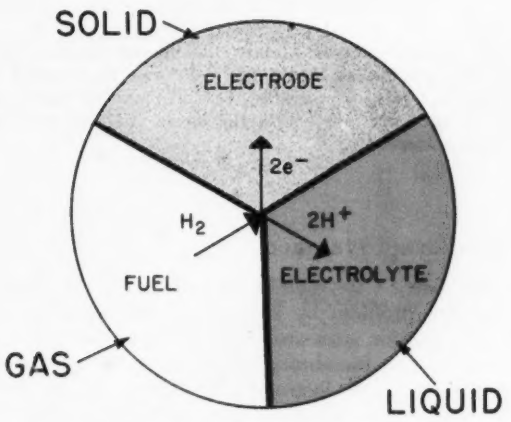

Fig. 2 Schematic of the hydrogen electrode of an acid-type cell. Obtaining enough triple contact reaction sites in a given volume is a problem.

simultaneous triple contact (solid-gas-liquid) remains relatively stable. Consider what happens when there is a pressure imbalance between the gas and liquid. If the gas covers the electrode, excluding the electrolyte, ion flow is interrupted. If the electrolyet drowns the electrode, excluding the gas, electron flow is interrupted. In either case cell action ceases.

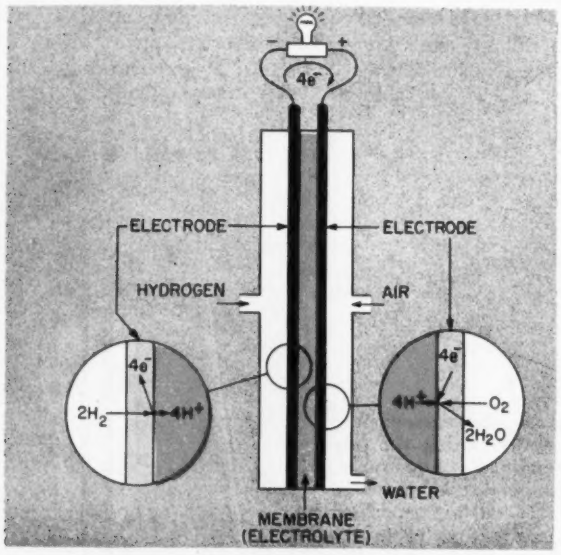

Fig. 3 General Electric's solid electrolyte fuel cell. Hydrogen and air enter chambers on opposite sides of the ion-permeable membrane and penetrate the porous electrodes to contact the surfaces of the membrane. On the oxygen side the electrons are given up, collected in the electrode and conducted to the load. The hydrogen ions travel through the solid electrolyte to the other surface of the membrane where they combine with the returning electrons in the presence of oxygen. Result: the formation of water and the release of useful electrical energy. Water droplets form on the open-air side and drain off. No special condensation equipment is required to accomplish this drain-off. (In other cell types where water forms in the liquid electrolyte there is a removal problem.)

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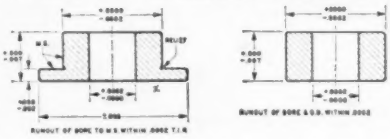

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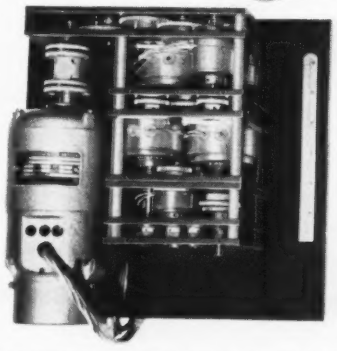

This rugged, miniature Dynaco transmission is available with up to 15 speeds, in any range from 3.3 to 7812 RPM. Dynaco gears are 303 stainless, 24 ST aluminum and DuPont DELRIN which has excellent resistance to wear and reduces noise factor. All shafts are 303 stainless.

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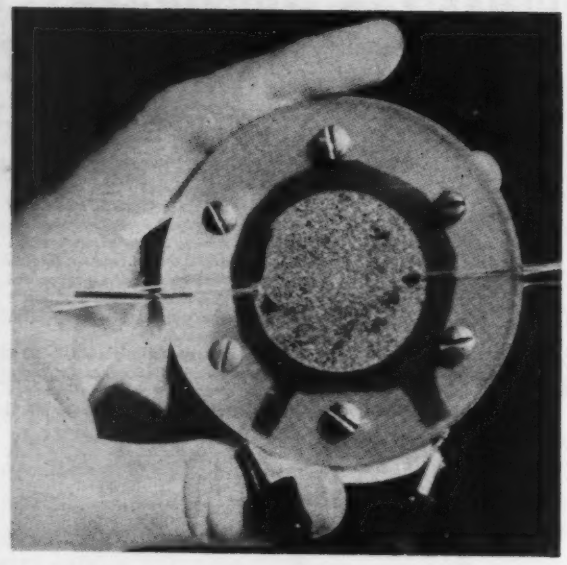

Fig. 4 Demonstration model of ion-membrane cell. Individual fuel cells produce approximately one volt. Since their current depends on the area of the membrane, cells are presently being made in sizes from four-inches square to one-foot square. Actually, there appears to be no theoretical limit to the size of the membrane, but practical considerations such as system reliability, thermal coefficients, and fabrication machinery will dictate the upper limits. Only 1/4 to 1/2 inches thick, the cells can be stacked in modules, series or parallel, to form useful blocks of power that are subject to the same rules as conventional batteries.

SOLID ELECTROLYTE CELL

General Electric's ion-membrane cell solves the triple contact stability problem by eliminating the liquid phase entirely. All reaction sites are "frozen" by use of a solid electrolyte—a plastic membrane which permits hydrogen ions to migrate from one electrode to the other. Fig. 3 illustrates the reactions in the cell and a demonstration model is shown in Fig. 4.

Advantages of the new cell are:

- No need to handle, pump or contain caustic liquid electrolytes.
- It operates at room temperature and normal pressure.
- High power-to-weight and power-to-volume ratios.
- Silent operation with nothing to wear out.
- Self-regulating; no external control of fuel power required; fuel is consumed only on demand.
- Capable of operating at zero gravity with high resistance to shock and vibration.
- High fuel efficiency; thermal efficiency about 60 percent under typical load (15-20 amp/ft^2) and improves under light loads.

A system shown in Fig. 5 suggests one method of using the cell for emergency power. Electric current is instantly available even if the commercial ac power is interrupted.

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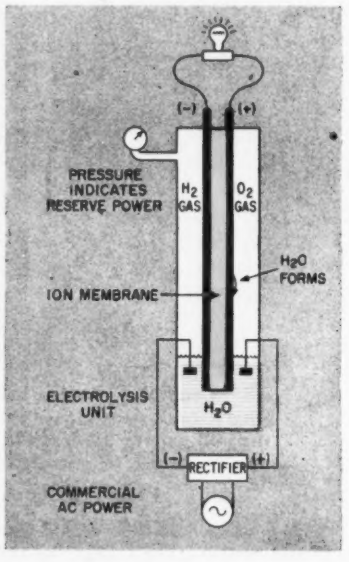

Fig. 5 Emergency power system using the ion-membrane fuel cell. Commercial ac power is rectified to dc which electrolyzes water in the bottom of the cell. Hydrogen and oxygen gases, stored on either side of the membrane, recombine to produce useful, steady dc power. The water returns to the bottom of the cell. A pressure gauge indicates the charge in the cell at any time. Water level regulates the electrolysis unit. When the level falls and exposes the electrodes, electrolysis ceases. Advantages of the system are: isolation of loads from commercial power; steady dc power without interruption; instant emergency power upon failure of commercial power; positive indication of emergency capability; inherent reliability through simplicity, no moving parts vent-free operation to permit sealing off from atmospheres.

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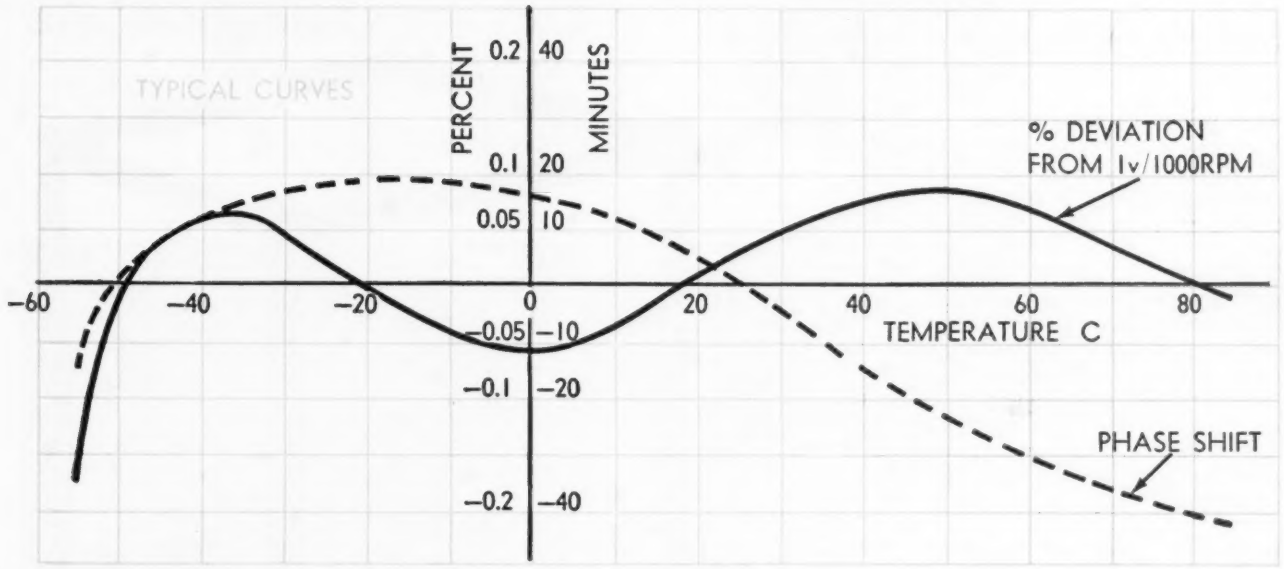
New Ketay size 15 integrating motor tachometer —

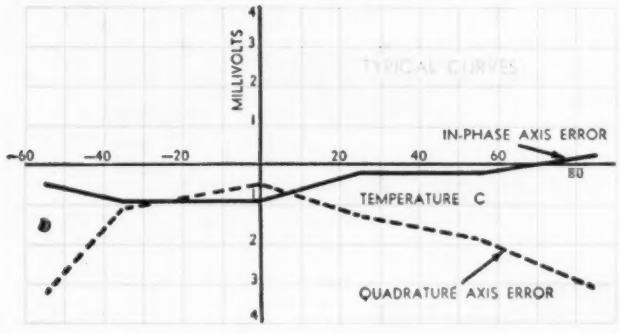
- **REQUIRES NO WARM-UP TIME**
- **USES NO HEATERS**
- **HAS 1.0000 VOLT PER 1000 RPM OUTPUT GRADIENT OVER ENTIRE TEMPERATURE RANGE**



The Ketay integrating motor tachometer, Type 105P2Y has many features that assure high output-to-null voltage ratios and extreme accuracy over the entire temperature range of —55°C. to +80°C.

In addition, the Type 105P2Y will give instantaneous response, for no warm-up time is required at any temperature within the operating range. The Ketay design uses no heating elements, mechanical thermostats, amplifiers or external heat sources and, as a result, the unit has increased life, less weight and less power drain on the over-all system.

The unit will pass military environmental specifications called out in MIL-S-17806.



CHECK THESE GENERATOR SPECIFICATIONS:

Excitation (volts)	115
Frequency (cps)	400
Input current (nominal) amps	0.0275
Input power (nominal) watts	1.9
Output gradient per 1,000 RPM @ 25°C.	1.0000 ± .05%
Phase shift with respect to input at 3600 RPM @ 25°C.	0° ± 10′
Null voltage at 25°C. (Maximum Values)	
IN-phase Fundamental at zero speed	2MV
Quadrature Fundamental at zero speed	6MV
Total harmonic	10MV(RMS)
IN-phase axis error	1MV
Quadrature axis error	1MV
Linearity —0 to 4000 RPM (percentage of voltage output at 3600 RPM)	± .06%
Variation in output gradient with variation in ambient temperature (—55°C. to +80°C.)	± 0.2%
Variation in axis error with variation in ambient temperature (—55°C. to +80°C.)	± 7MV ± J8MV
Variation in phase shift with variation in ambient temperature (—55°C. to +80°C.)	± 1°
Warm-up time	None
Total unit weight (motor and generator)	15 oz.

Write for detailed specifications and drawings, or for information on other Ketay integrating and damping tachometers.

KETAY DEPARTMENT

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DIVISION OF UNITED AIRCRAFT CORPORATION
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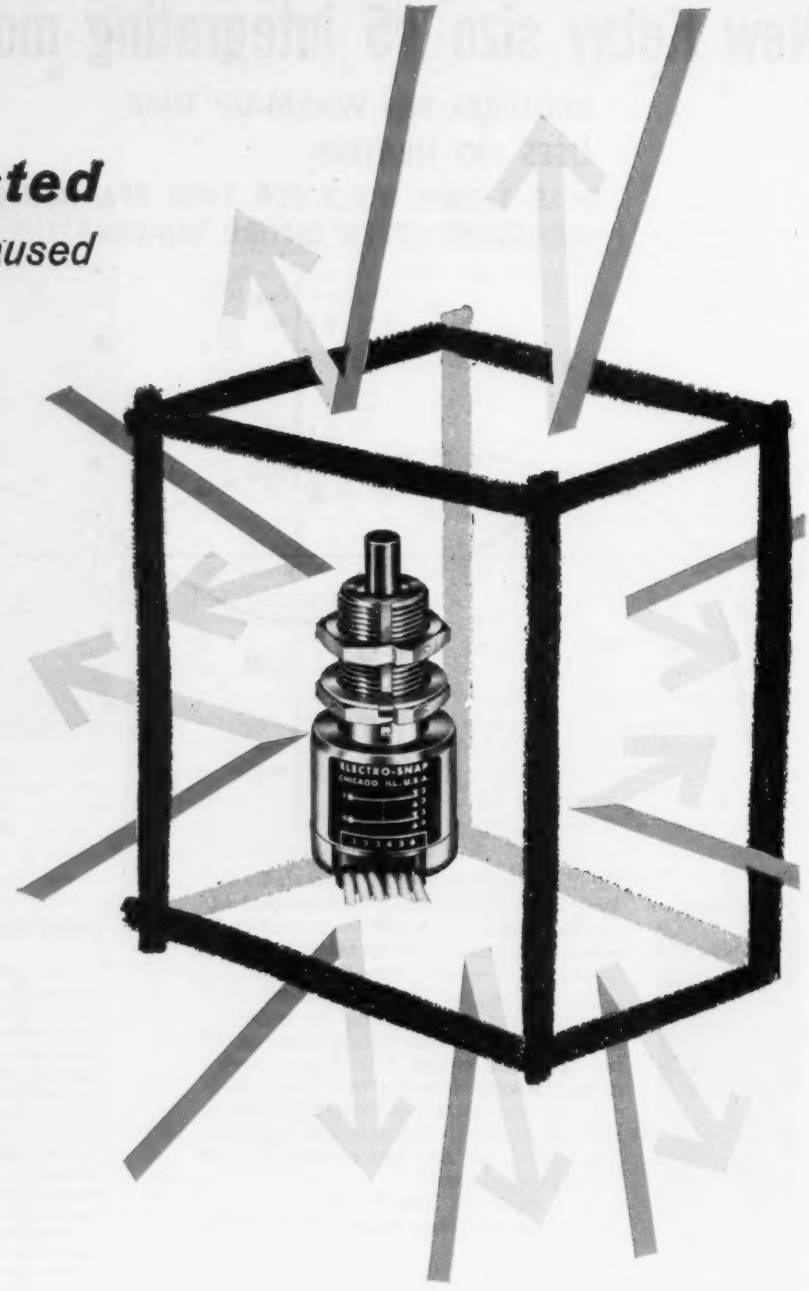

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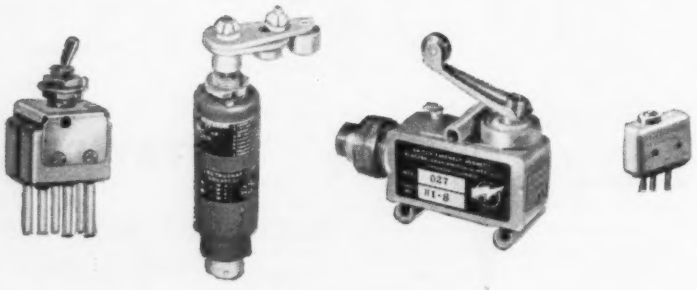

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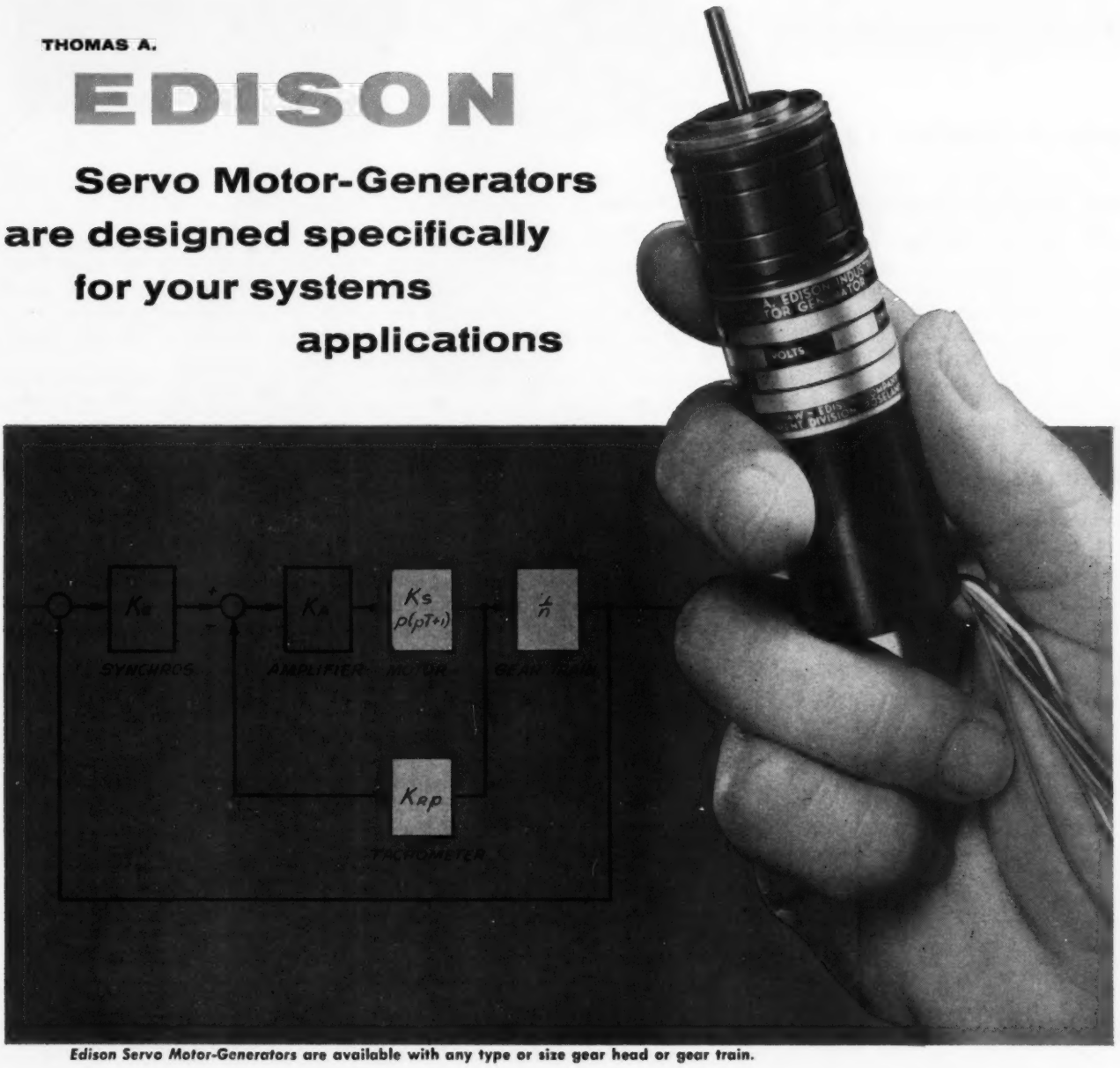
THOMAS A.

EDISON

Servo Motor-Generators are designed specifically for your systems applications



Edison Servo Motor-Generators are available with any type or size gear head or gear train.

Unlike ordinary "off-the-shelf" components, Edison Servo Motor-Generators are designed specifically to operate as part of an electro-mechanical system.

For example, their motor sections are built to have minimum time constants and reversing times. To insure precise coupling with mating gear trains, output pinions are fabricated *to better than AGMA standards.* Damping constants, from unit to unit, are held to very close tolerances.

In addition to these special system features, Edison Servo Motor-Generators are made to the highest quality standards. They outperform MIL-S-17087 (for motors) and MIL-S-17806 (for generators).

Edison engineers provide you with the exact servo motor-generator your system calls for—not a cataloged component that will only approximate your needs. For this reason, they will work closely with you in developing components that will assure you of the best system performance.

For additional information on Edison Servo Motors, Motor-Generators and other rotary components, write for Catalog 3044.

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INSTRUMENT DIVISION
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McGRAW EDISON

CIRCLE NO. 28 ON INQUIRY CARD

DISPLACEMENT TRANSDUCER

High Power Sensitivity Simplifies System Design

In designing instrument and control systems, engineers are frequently faced with the problem of obtaining a highly sensitive displacement transducer. The Transipot, a rotary or linear displacement pickoff developed by Arnoux Corp., L. A., Calif., meets this need with sensitivities as high as 1 volt per milli-inch of linear displacement or 1 volt per degree of angular displacement.

OPERATION

Transipot's operation can be described as that of a bridge circuit in which the series reluctances of the magnet's circuit are the variable parameters. Fig. 2 shows that the differential variations in reluctance are based on a variable-area mode of operation and that each half of the magnetic circuit is half engaged at the null position.

In both rotary and linear models, one half of the available iron cross-section is engaged by each end pole at the null position. With variation of the shaft input, the alternate ends inversely vary the cross-sectional area of the gaps in the magnetic circuit, thus providing a differential mode of operation.

Operation voltage may be compared to that of a push-pull amplifier circuit in which the effect of symmetrical nonlinearity is cancelled. The null point in the center of the linear range is comparable to a class A amplifier. When the load is equal to the source impedance, the output power is maximum. When the load is several times the source impedance, linearity is maximum.

Output and input impedances consist of all normal parameters of a transformer. However, the significant difference is a large variable reluctance. Maximum performance is obtained by careful control of the symmetry of these reluctances. Because of the differential function, both input and output impedances are constant over the range of the instrument (except in d-c output models where load current is a factor in the output impedance of the unit).

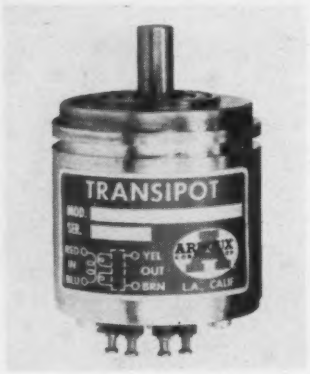


Fig. 1. Arnoux Corp.'s Transipot is designed for optimum performance at 400 cycles. However, excellent operation may be obtained over a frequency range of 300 to 6000 cycles. Designs for other frequencies can be supplied on special order.

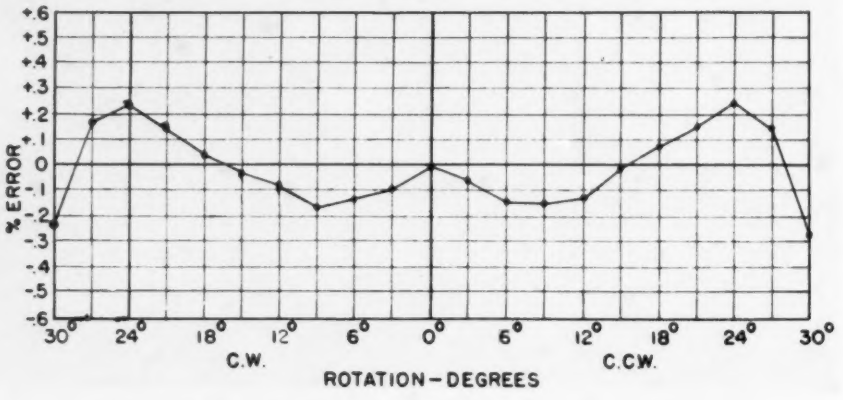


Fig. 3. Typical linearity curve.

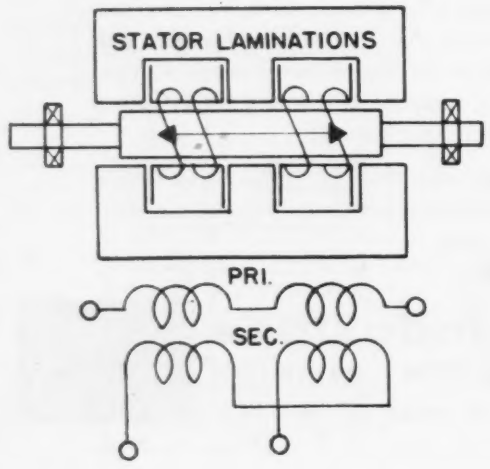
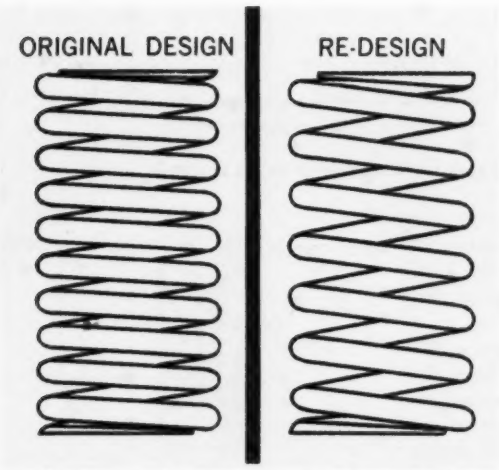


Fig. 2. Typical configuration of a linear stroke Transipot. A closely coupled magnetic path is formed between the rotor and the stator, represented by standard E laminations. Differing in orientation from those of the normal motor or synchro, the laminations lie in the plane through the shaft axis. This permits two simple bobbins to be inserted in the E structure, simplifying the winding problem and eliminating the need for space-winding the coil. The rotor is also laminated in the same plane as the stator. Rotary models have the same basic configuration as the linear-stroke models except that the stator and rotor stacks are split into sections dictated by the range desired. Stators of all models are through-bored, assuring a high degree of concentricity between hearings and the magnetic structure. Stator laminations are stacked radially and tightly together around the mandril during casting, and the finishing of the stator bore removes the tips of the laminations. This construction restores a high degree of insulation between laminations and insures against eddy-current losses in the magnetic circuit. Interlamination cogging effect is not distinguishable due to the combination of lamination thickness and air-gap length and because the rotor and stator laminations are of different thicknesses. Consequently, the output is extremely smooth, with no abrupt slope changes.

70 POUNDS OF SPRINGS

were just going along for the ride!



10 coils—.120″ wire
130 lbs. of wire per
1M springs

7 coils—.105″ wire
60 lbs. of wire per
1M springs

Because of mounting cost conditions, a user of motor-support springs asked for a complete design check. Redesigned by A.S.C. engineers, required stresses were met by a slight change in wire size, allowing a reduction in number of coils from 10 to 7. This meant a saving of 70 pounds of material per thousand springs. Because of the shorter length of wire, coiling and grinding speeds were increased, heat-treating time reduced. Saving to the customer—40%.

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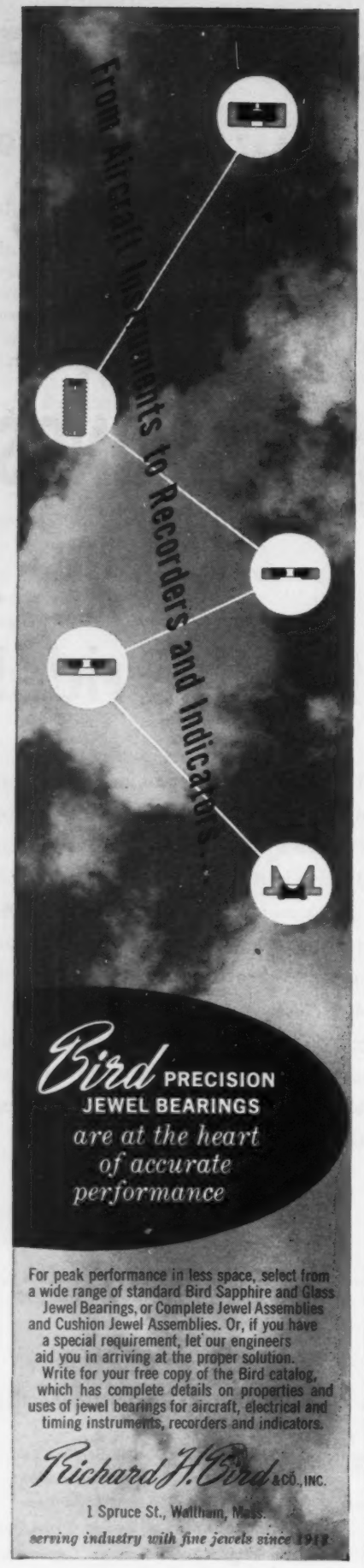
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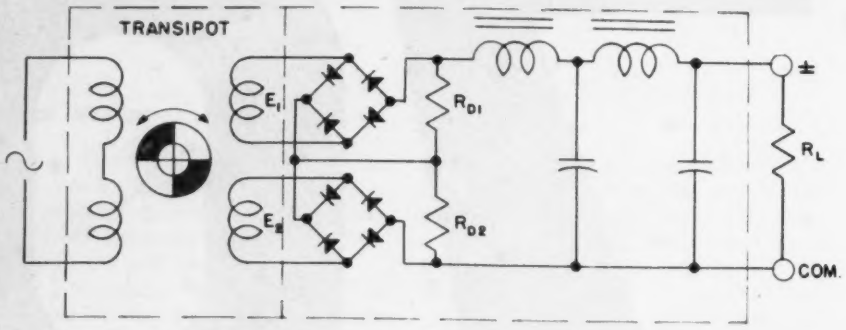


Fig. 4. Demodulation circuit consists of two diode bridge rectifiers, with outputs connected in series-opposing and inputs connected separately to the two output windings of the Transipot. Secondary voltages are never closer than several hundred percent of the diode threshold voltage, thus eliminating threshold effects. Consequently, output linearity is preserved down to the null, allowing the sensing of angular changes approximating 1 second of arc or less.

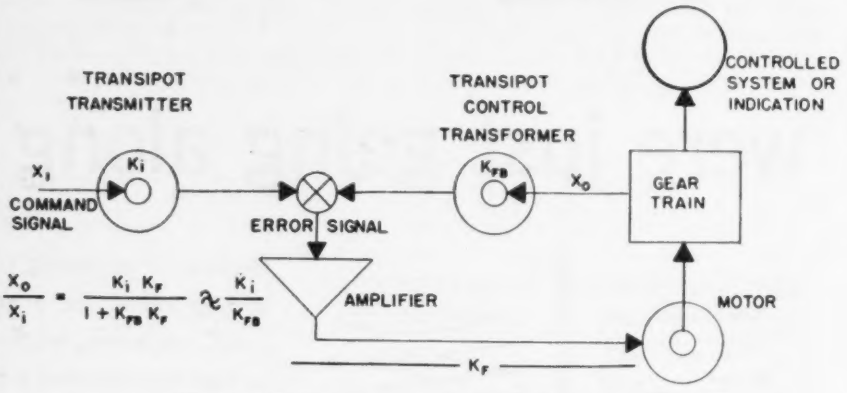


Fig. 5. A basic servo system for position control.

Due to these constant impedances, linearity is relatively immune to loading. Typical linearity curve is shown in Fig. 3.

Transipot has four windings, a primary and a secondary for each of the opposing magnetic circuits located on the stator structure. Connection of the primaries is series-bucking and secondaries, series aiding. Thus, when the magnetic circuits are balanced or equal, each secondary has an equal induced voltage but of opposing phase, producing a net voltage of zero at the output terminals. Actually, the null voltage contains some harmonics and a small amount of fundamental frequency. The fundamental component can be balanced out by a resistive shunt between the center tap and one side of either primary or secondary windings. Remaining harmonics are of the order of 0.01% of full-scale output voltage and can be reduced when the output is tuned to the fundamental frequency or by appropriate filtering.

If d-c output is desired, a separate demodulator unit is available to cen-

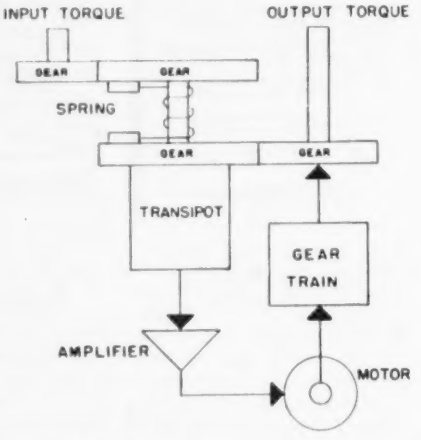
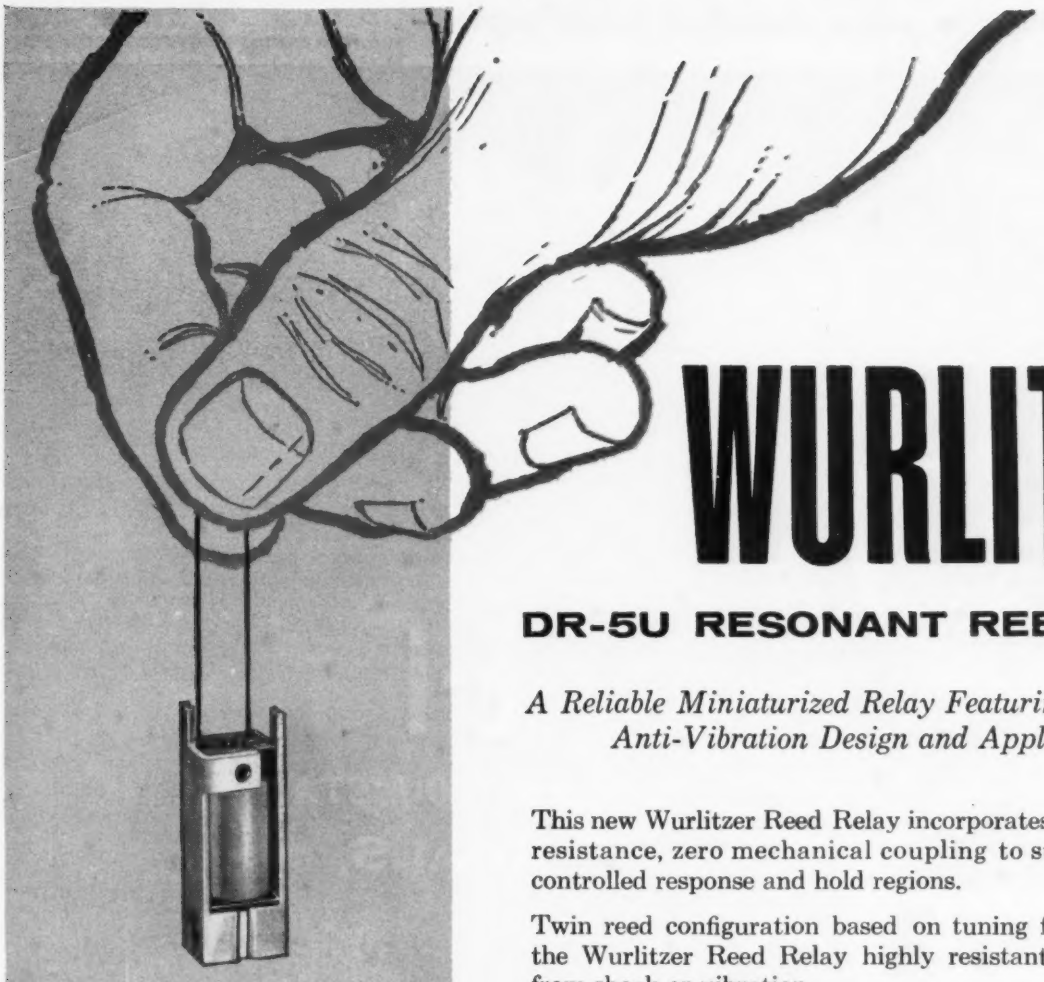
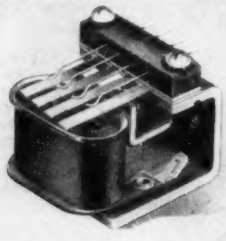


Fig. 6. Power boost system, in which coupling between the rotor and stator gears provides the operator with an artificial "feel" of the load.



Uncased Resonant Reed Relay

Hermetically Sealed Resonant Reed Relay



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Sensitivity at the 2% bandwidth level is less than 1.0 milliwatt.

32 channels at 4% increments between 300 to 1000 cps.

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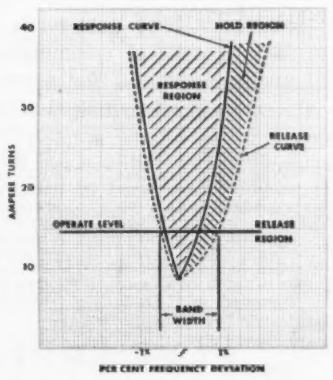

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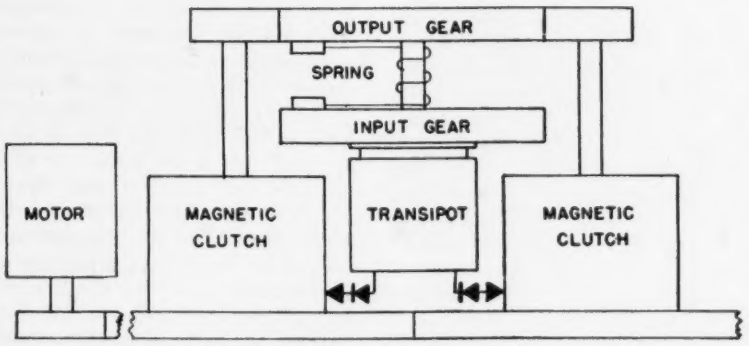

Fig. 7. Torque amplifier power boost system. Torque output is proportional to the torque input rather than input position. Spring coupling between input and output is made quite stiff so that input loading is a direct reflection of load, providing a true "feel" of the load on a reduced scale. The proportionality of input to output torque hinges upon the linearity of the relationship between input current and slip-torque of the clutch. Linearity is adequately provided for by the use of powder magnetic or hysteresis clutches.

ter-fit on the rear of the basic Transipot, eliminating problems of diode threshold and providing linearity of output identical to the basic unit. A schematic of the demodulator is shown in Fig. 4.

APPLICATIONS

In a basic servo system for position control (Fig. 5), the high sensitivity of the Transipot simplifies the system's amplifier, or, in some cases, avoids the need for an amplifier. Generally the Transipot is sufficient to drive the power stage of the amplifier directly; a d-c output unit is used in the case of magnetic amplifiers.

In many aircraft and missile applications, as well as in power machinery, it is necessary to provide a power boost for the operator or the basic control device. A power-boost system, shown in Fig. 6, is generally used to position the load to the command signal or input position. This system and the more complex design shown in Fig. 7 have been used in aircraft control surface boost systems.

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WORTH FILING

Data Translation System

16-pages on a computer language translation describes data translation capabilities, basic translation system and common translation modes. The system provides rapid and efficient translation of data between different types of automatic data processing systems. Magnetic tape recorded in the format of one computer can be translated directly to magnetic tape usable by a different computer. Translation between radically different types of media such as punched cards, paper tape, and magnetic tape can also be accomplished by the system.

Source: Electronic Engineering Co.
Santa Ana, California

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Relays

41-page relay manual lists 30 types of relays, (with 1,000 variations) for communications and computers for industry and the military. Manual includes line drawings, tables and other detailed data on pile-up relay types, variations in spring arrangement, timing, coil voltage and contact ratings.

Source: Diaphlex Div.
Cook Electric Co.
Chicago, Illinois

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High Tensile Bolts

32-page design manual reports that a newly-developed thread form will at least double the fatigue endurance of a standard high-tensile bolt. 17 pages are devoted to findings related to the basic nature and causes of fastener fatigue. Photoelastic comparisons between standard and improved nuts provide a visual explanation and verification of the drastic load redistribution accomplished by the new thread form.

Source: Elastic Stop Nut Corp. of America
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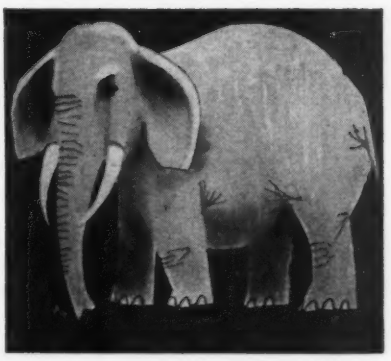
LIGHTWEIGHT

RUGGED



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COMPONENTS DESIGN

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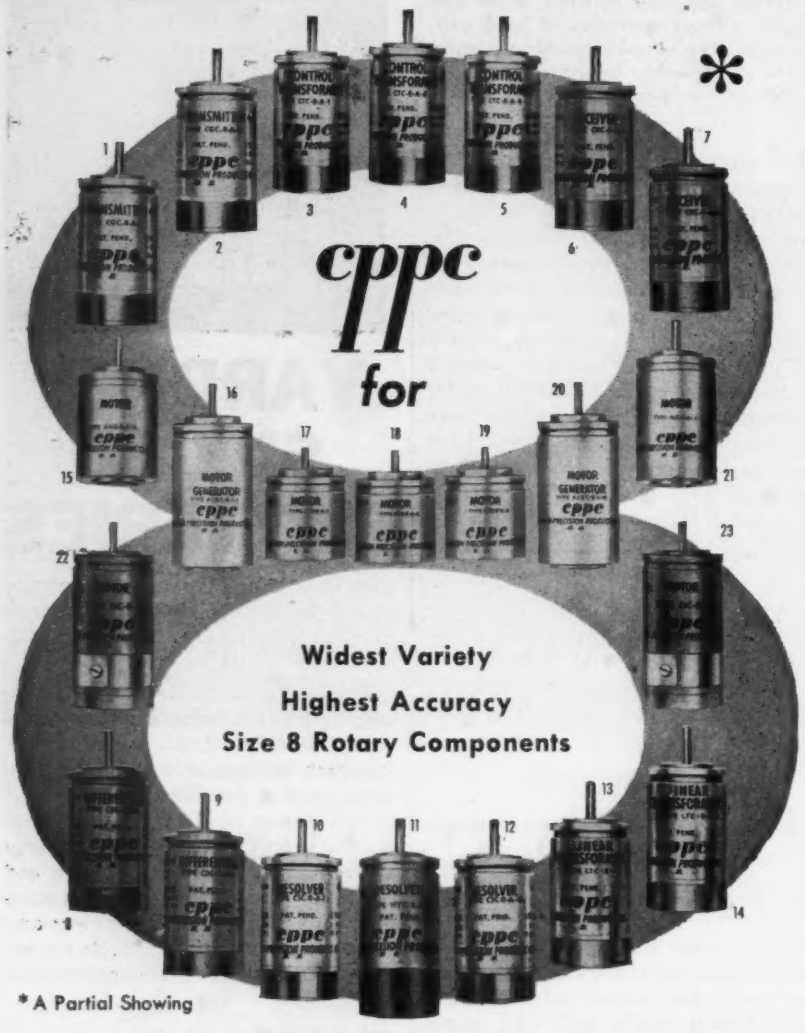
Heat Exchangers

Due to advanced production design and manufacturing techniques, cold plate heat exchangers provide higher thermal efficiencies and lighter weight than conventional heat transfer equipment, according to the manufacturer. The compact unit uses corrugated aluminum strips brazed to the face plates to provide conductive media for the flow of liquid or gaseous coolants. The maximum air pressure drop is 3.46 inch H_2O at a rated air flow of 2 lbs/min at an ambient temperature of 160°F. Minimum heat removal capacity is 8.5 BTU per minute (150 watts). Horkey-Moore Associates, Torrance, Cal.

Write No. 524 in Box on Inquiry Card



* A Partial Showing

Clifton Precision's size 8 rotary components have been tried and proven by customers over the past 4 years. More than 50,000 have been shipped. These are the most accurate and best tested (because they are use tested) size 8 rotary components on the market today.

1. Torque transmitter (26v. input) 2. Torque transmitter (115v. input) 3. Control transformer (lo Z) 4. Control transformer (hi Z) 5. Control transformer (very hi Z) 6. Torque receiver (26v. input) 7. Torque receiver (115v. input) 8. Torque differential (lo Z) 9. Torque differential (hi Z) 10. Electrical resolver (.5 t.r.) 11. Precision computing resolver (feedback winding) 12. Electrical resolver (1 t.r.) 13. Linear transformer (115v. input) 14. Linear transformer (26v. input) 15. Servo motor (1" length, .40 in-oz stall torque) 16. Motor generator (10v. input) 17. Servo motor (53/64" long) 18. Servo motor (35v. center tap) 19. Servo motor (26v. center tap) 20. Motor generator (26v. input) 21. Servo motor (.30-in-oz stall torque) 22. D.C. motor (14v. input) 23. D.C. motor (28v. input)

CLIFTON PRECISION PRODUCTS CO., INC.

CLIFTON HEIGHTS, PA.

Sales Office: 9014 W. Chester Pike, Upper Darby, Pa.—Hilltop 9-1200, TWX Flanders, Pa. 1123

cppc

CIRCLE NO. 36 ON INQUIRY CARD

Particle Counter

Automatic sampling and measuring of contamination in fluid systems are obtained with the Hiac Particle Counter. Fluid to be tested can be pumped directly through the unit. A representative sample is taken automatically and caused to flow past the window in a stream so small that the foreign particles in the fluid pass the window one by one. A light beam is directed through the window and the fluid stream so as to impinge on a photosensitive element on the opposite side of the stream. As a foreign particle in the fluid stream passes the window, a portion of the light beam is interrupted. This causes a change in the output signal from the photosensitive element which is proportional to the size of the particle interrupting the light beam. This signal change is amplified and sent to counter circuits which have been adjusted to various sensitivities. The particle is then tallied according to its size. Absolute calibration is obtained with a transparent disc containing particles of known sizes which can be rotated back and forth to interrupt the light beam. Accurate results can be quickly obtained in laboratory, factory or field. High Accuracy Products Corp., Claremont, Calif.

Write No. 525 in Box on Inquiry Card

Automatic Coating of Components

Accurate coating of coaxial lead components by spray methods at a rate of 4000 per hour is obtained with the use of a machine called the Remote Masking Spray Coater. A resinous composition, such as an epoxy compound, is confined to the desired area by two accurately spaced traveling strips, while racks, loaded with diodes, move continuously through the spray station. The diodes, while in the racks, are spun so as to assure application of an even coating. Coating is applied to the diode only and desired portions of its lead wires so as to prevent cracking of the coating if the wires are bent for insertion in a printed circuit board. There is no excess coating to interfere with soldering. Diodes remain in the racks for one handling of both the spraying and baking operation.

Automation is possible, inasmuch as the coating material is confined by remote masking and not mechanical means, thus eliminating the use of spray masks, registering devices and mask cleaning operations. The machine may be adjusted to accommodate coaxial lead components of varying lengths. Conforming Matrix Corp., Toledo, Ohio.

Write No. 526 in Box on Inquiry Card

Hermetic Sealing

Manual details the basic steps and applications for electro-sealing. The process for hermetic sealing was developed for military requirements and is now being widely employed in many commercial products where improved reliability is desired. Not only are single components hermetically sealed, but the process is successfully employed to seal entire assemblies. Manual illustrates applications such as complete timer mechanisms, electronic amplifiers and centralized remote control gear that has been sealed by the process.

Source: Electro-Seal Corp., Des Plaines, Ill.
For your copy: Write No. 528 on Inquiry Card

Pressure Measuring Elements

16-page catalog describes characteristics of both conventional capsule and nested capsule types of diaphragm elements. Dimensions, travel, rated and maximum pressure, linearity, spring rate and deflection rate are listed for elements made from Ni-Span-"C". The heat treatable alloy, Ni-Span-"C" has an almost constant spring rate over a temperature range of −50 to +200F. Tables also list dimensions, specifications and materials of Bourdon tube elements. Also listed are factors required in specifying both types of elements.

Source: U. S. Gauge Div., Amer. Machine and Metals, Inc.
Sellersville, Pa.
For your copy: Write No. 536 on Inquiry Card

Diaphragm Bellows

16-page design guide presents the story of welded diaphragm bellows from their basic physics through applications. Included are drawings and specifications of the bellows as well as illustrations of the different types: the flexible, expansion and pressure types. Basic to the design guide is a discussion of the differences between formed and welded bellows the value of each and their relative place in equipment design.

Source: Breeze Corps., Inc.,
Union, N. J.
For your copy: Write No. 537 on Inquiry Card

Capacitors

28 pages provide detailed information on standard commercial, Mil-C-25A, and Permafil capacitors used for ac-dc applications. Complete rating and dimension tables are included for applications ranging from 100 to 50,000 vdc and from 236 to 660 vac. In weight, units described range from a few ounces to 150 lbs.

Source: General Elec., Schenectady, N.Y.
For your copy: Write No. 535 on Inquiry Card

Faced with the problem of transmitting rotating power and control signals, D. S. Kennedy & Company, a leading manufacturer of radar and tracking antennas, called upon the leading producer of slip ring assemblies — ELECTRO-TEC!

Electro-Tec engineers developed a completely self-contained, prealigned, easily mounted slip ring "package" for the giant 60′ dish type antenna Kennedy was producing for a tracking radar.

Fitting into a 4′ high by 20″ diameter housing, the slip ring assembly contains 118 circuits — 8 sixty amp., and 110 twenty amp. of which 40 are shielded for ultra-low noise.

This is typical of the many successful design and manufacturing applications which Electro-Tec performs for leading manufacturers of radar, gyros, inertial guidance, instruments, and switching.

*Pat. No. 2,696,570 and other patents pending

Write for illustrated literature

ELECTRO-TEC CORP. SLIP RINGS • SWITCHES RELAYS

P. O. BOX 37S, SOUTH HACKENSACK, N. J. • BLACKSBURG, VA., ORMOND BEACH, FLA.

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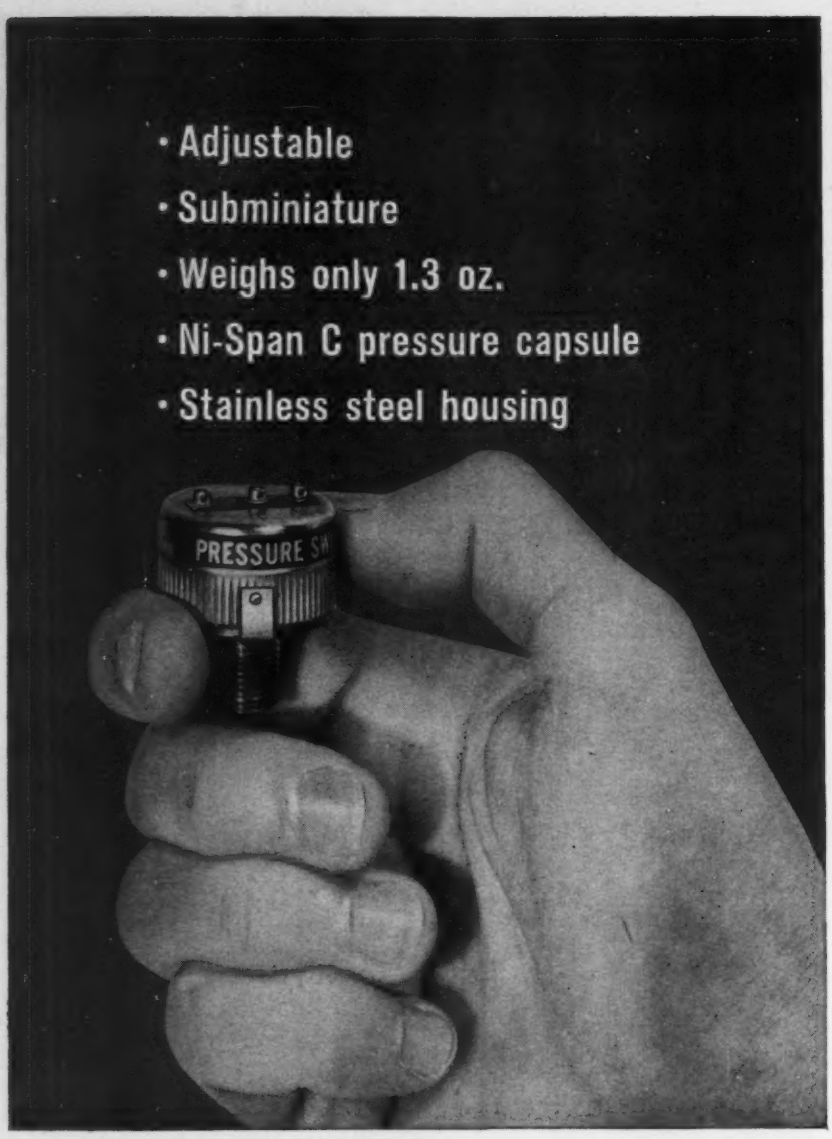


NEW BRISTOL PRESSURE SWITCH

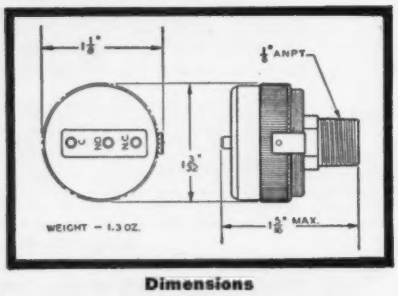
Here's a subminiature pressure switch that incorporates the superb reliability characteristics of larger Bristol pressure switches. Yet, it's both miniature in size and it's adjustable.

It's the Bristol Type C2060 . . . with six models covering ranges from 2-15 psi, absolute, to 20-200 psi gauge.

Easy pressure adjustment. You can change pressure settings easily and simply, without tools. Just turn the top portion of the switch. A strong ball detent holds settings positively even under severe vibration and shock.

Withstands shock, vibration, and acceleration in excess of MIL-E-005272B requirements. SPDT snap-action contacts are rated at 5 amps, 125vac, 60 cps; 2.5 amps d-c resistive load.

Get complete specifications on the new Bristol adjustable pressure switch today. Simply write for Bulletin AV 2015. The Bristol Company, Aircraft Equipment Division, 181 Bristol Road, Waterbury 20, Conn. O.14



Dimensions

BRISTOL FINE PRECISION INSTRUMENTS FOR OVER SEVENTY YEARS

CIRCLE NO. 34 ON INQUIRY CARD

WORTH FILING

Testing Instruments

16 page folder contains specifications, application information and prices of six portable potentiometers, two dc galvanometers, an ac and a dc null detector, a guarded Wheatstone Bridge facility, a students' potentiometer, a universal ratio set and two electrolytic conductivity indicators.

Source: Leeds & Northrup Co., Phila., Pa.
For your copy: Write No. 532 on Inquiry Card

Alloy Preforms

20 page comprehensive booklet covers design considerations and examples of metal joints which lend themselves to use of brazing alloys in preformed shapes. Included are comparisons of preform versus hand feeding; applications of round wire rings, flat wire rings, mandrel wound rings and no-tangle notch-coil rings. Booklet also deals with edgewound and blanked washers, new curved washers and shims. Material selection chart on various gold, silver, aluminum and soft solder alloys covers composition, melting points, flow points and general characteristics. The importance of flux, types of fluxes and methods of flux application is outlined and a section is devoted to the use of preforms in the electronics industry.

Source: Lucas-Milhaupt Engin. Co., Cudahy, Wisc.
For your copy: Write No. 531 on Inquiry Card

Microwave Components

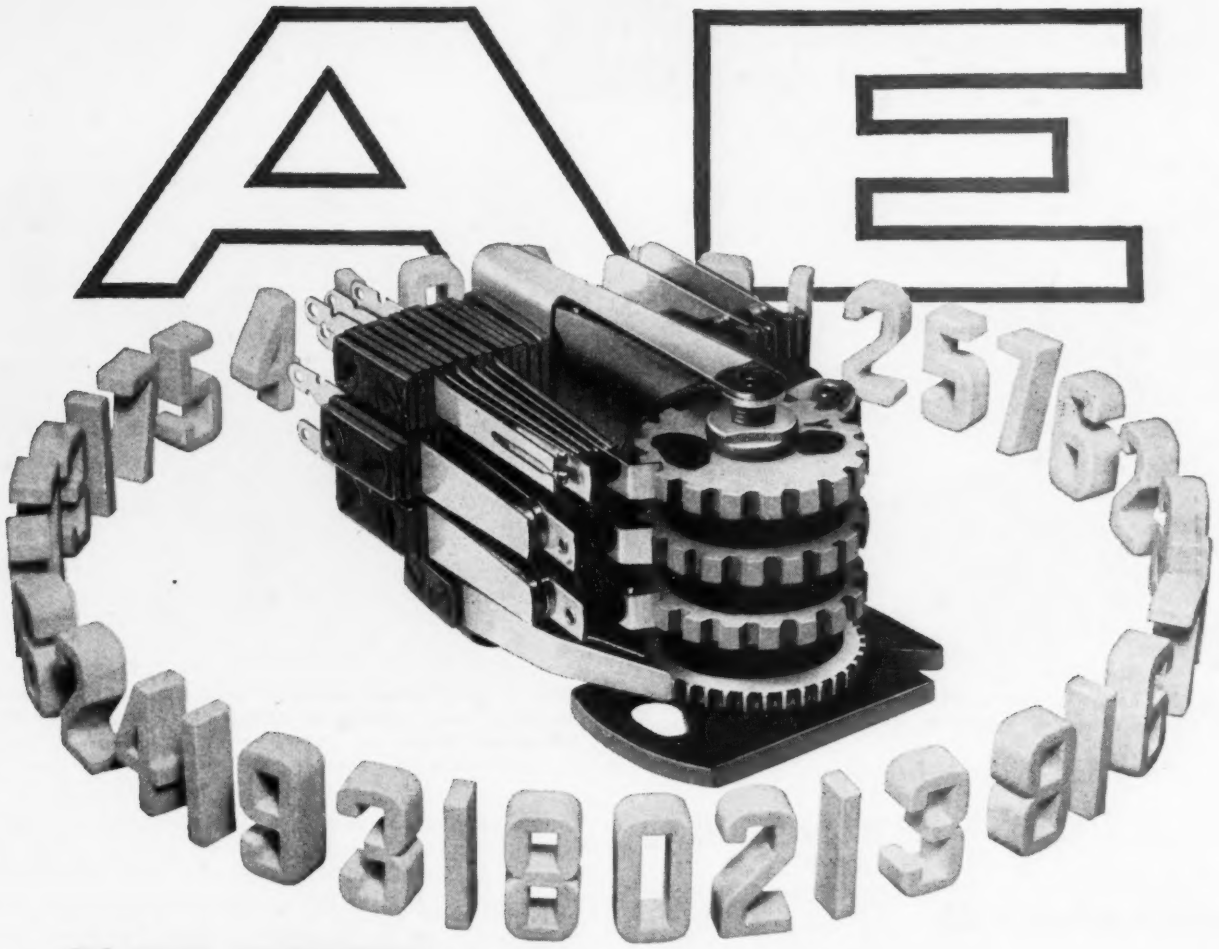
48 page catalog describes entire line of noise and field intensity meters, impulse generators, power density and modulation meters, coaxial attenuators and terminations, crystal mixers and microwave components. Also included are descriptions of a representative sampling of special products.

Source: Empire Devices Products Corp., Amsterdam, N.Y.
For your copy: Write No. 534 on Inquiry Card

Temperature Controls

12 page bulletin describes simple and inherently stable temperature control packages known as Simplytrols which are applicable to a wide variety of industrial processes. Bulletin explains operation, circuitry and safety features of three basic types of thermocouple-actuated units including a proportional model that is capable of holding temperature to ± 1 F of set point.

Source: Assembly Products, Inc., Chesterland, Ohio
For your copy: Write No. 527 on Inquiry Card



TO THE ENGINEER

who can't tolerate a lapse of memory

If you're working on a think machine that can't afford to break its train of thought, consider AE's pint-size, fast-stepping OCS switcher. Unlike electron tubes and relays, this sophisticated device won't lose stored memory in the event of power failure or circuit interruption.

Besides, it can do the work normally assigned to whole banks of relays.

The AE Series OCS will follow or initiate a prescribed series of events or cycles at 30 steps per second impulse-controlled, or 65 steps per second self-interrupted. Any programming sequence can be set up on one to six cams with as many as 36 on-and-off steps per cam. And each cam will actuate as many as six contact springs.

In any event, if your designs involve relays or stepping switches, AE circuit engineers may be able to save you a pretty penny. Or, if you'd like to leave the switching to us, we're equipped to supply prewired and assembled, custom-built control units, *or* help you develop complete control systems.

To explore the matter, just write the Director, Control Equipment Sales, Automatic Electric, Northlake, Illinois. Also ask for Circular 1698-H: *Rotary Stepping Switches;* Circular 1702-E: *Relays for Industry;* and our new 32-page booklet on *Basic Circuits.*

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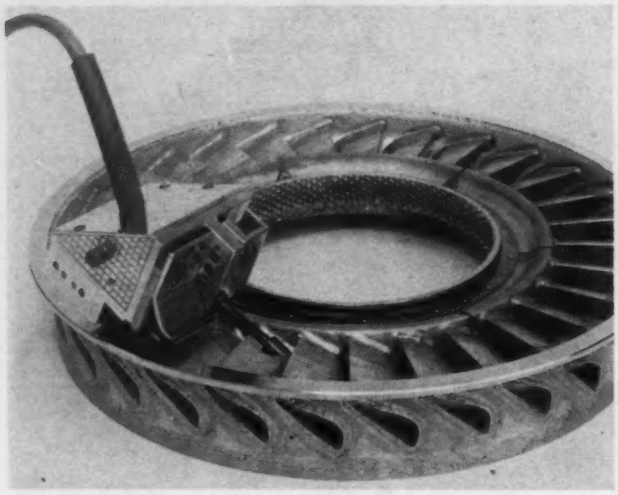


Fig. 1 The Narc area analyzer measures the air-flow area of each opening of a turbine nozzle.

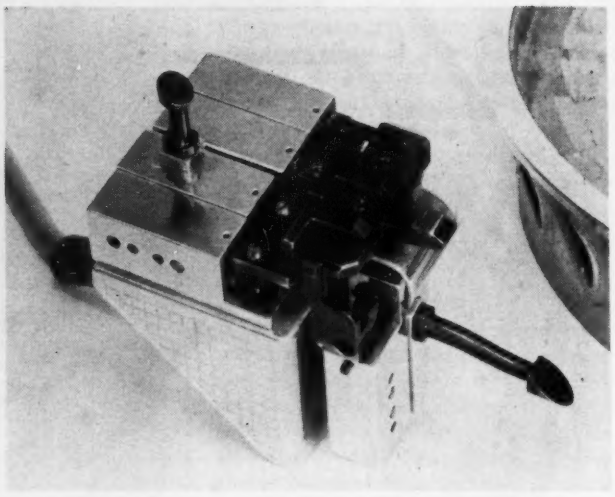


Fig. 2 Entire gauge assembly weighs less than 1 lb. Unit is free of any linkages or adjustments except those of the transducer cores.

AREA ANALYZER

System Simultaneously Measures Five Dimensions, Computes and Records Areas

Determining the maximum or minimum air-flow area of a turbine nozzle (or diaphragm) for an aircraft jet engine has been a tedious and inaccurate process. Fig. 1, showing a typical nozzle, indicates the problem such measurement represents. Determining the area of each opening requires gauging five dimensions and time-consuming computation. Repeatability and accuracy of such readings has varied widely and time required to gauge a single nozzle has ranged from one to four hours.

Intent on radically improving this operation, the Small Aircraft Engines Department of General Electric, of West Lynn, Mass., contracted with Stone Laboratories of Boston for development of the necessary equipment.

A nozzle area recording computer (called Narc) developed through joint effort of the two companies now provides the desired information in less than ten minutes with accuracies and repeatability better than 0.1 percent.

Gauging is accomplished by a special fixture housing five linear differential transformers which measure five dimensions within the opening between partitions or blades in the nozzle. As each opening area is computed, the system displays the deviations sensed by the transducers, pinpointing out-of-tolerance conditions. Combining these measurements, it computes, records and displays the area of that opening to an accuracy of one-thousandth of a square inch. After all the openings are gauged, the computer automatically produces a printed tape identifying each opening with its associated area and recording the total air flow of the entire nozzle.

Narc will compute the air-flow area of any nozzle with 1 to 400 openings ranging from 0.001 to 100 square inches. The system can be modified or adapted to compute and analyze practically any dimension, with significant savings in time and procedures as compared with less automated methods of gauging and inspection.

THEORY OF OPERATION

The gauge assembly is unique, in that it doesn't have any linkages or adjustments except those of the transducer cores. Each transducer is actuated by means of parallel springs, and all components are fastened and doweled to a single steel body.

To fulfill the design objectives the gauge was required to

- be lightweight
- locate on the partition with minimum effort, yet remain absolutely fixed during the measurement cycle.
- locate all five sensing elements at precise points on the partition, within 5/10,000 of an inch.
- provide electrical and mechanical repeatability to better than one percent
- withstand considerable handling and abuse.

These requirements were met in the final design illustrated in Fig. 2. An untrained operator can successfully measure flow area with the gauge after a minimum of ten minutes of instruction.

To adjust or preset the gauge, it is inserted into a steel master machined to the dimensions of a perfect nozzle opening. Each of the five transducer cores are then adjusted to produce zero output.

To operate the system, the gauge is inserted into an opening in the nozzle and located on the leading edge of the partition. It is then manually rocked causing the transducer to sweep the partition and sense a maximum and minimum deviation from nominal, as determined from the master.

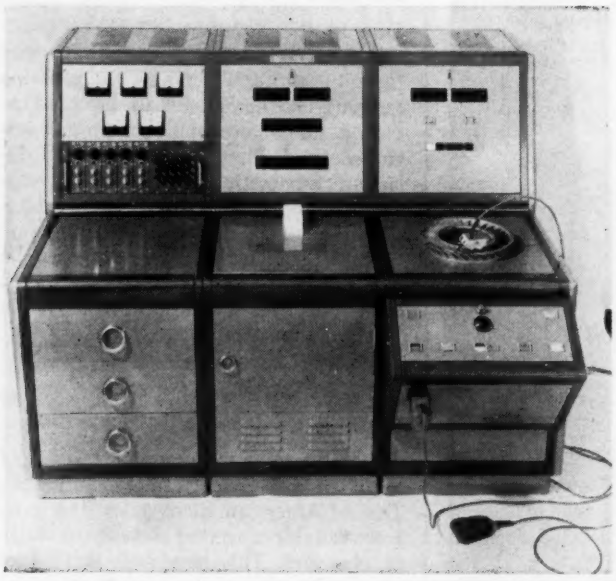


Fig. 3 Operation of the recorder computer is entirely automatic and can be adapted to analyze practically any dimension, with significant savings in time and procedures.

Operation of the recorder computer is entirely automatic. The output from each transducer is an error voltage equal in magnitude and direction to the deviation from nominal at the point of measurement. This voltage is rectified by a special amplifier which retains the voltage representing the minimum deviation sensed by the transducer. Voltages from all the transducers are converted in the computer to area deviations. The arithmetic sum of these deviations are added or subtracted from a preset nominal area. Final display and recording of data is in the form of true minimum flow area of that opening.

As an added feature, the true linear displacement of each transducer is indicated in mils, plus or minus, on five panel meters, to provide partition alignment information for use in analyzing and correcting manufacturing procedures.

AREAS OF EXTENSION

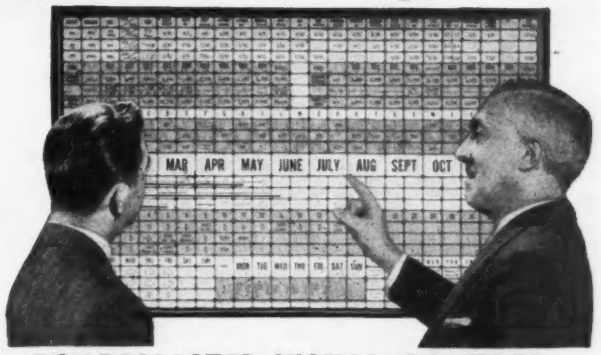
Although basically designed to analyze and compute areas of compressor nozzles, Narc can be expanded or revised with little or no internal changes for the purpose of checking the dimensional accuracy of almost any manufactured product.

The five transducer inputs can be individually selected, used differentially, or combined to measure tolerance in length, width, height, area or volume. An important characteristic of the output presentation of the computer, both visually and recorded, is that it indicates actual dimension, not deviations. If desired, however, the presentation can be in the form of deviations.

As a sampling or recording device it can measure the parameters of an object passing through an assembly line or conveyor line, compute the product's dimensions and/or supply "go or no-go" signals to identify or reject the item. Each channel can accommodate transducers in the range of 0 to 5, 0 to 10, 0 to 25, 0 to 50 mils with resolution better than one part in 10^{-6}.

Write No. 154 in Box on Reader Inquiry Card

How To Get Things Done



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The Series RL & RLP are mechanical latch units which require only a momentary pulse for operation, thereby eliminating current drain and chatter.

SPECIFICATIONS:
Contact Ratings: 10 amps. non-conductive
Contact Arrangement: up to 6 PDT (open Type)
up to 5 PDT (plug-in Type)

For more information about the Series RL & RLP Latch Relay circle the reader service number below. However, if you want a copy of our complete catalogue, send your request to our new address as shown below.

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LINE ELECTRIC COMPANY
241 RIVER STREET • ORANGE, N. J.
AFFILIATE—INDUSTRIAL TIMER CORPORATION

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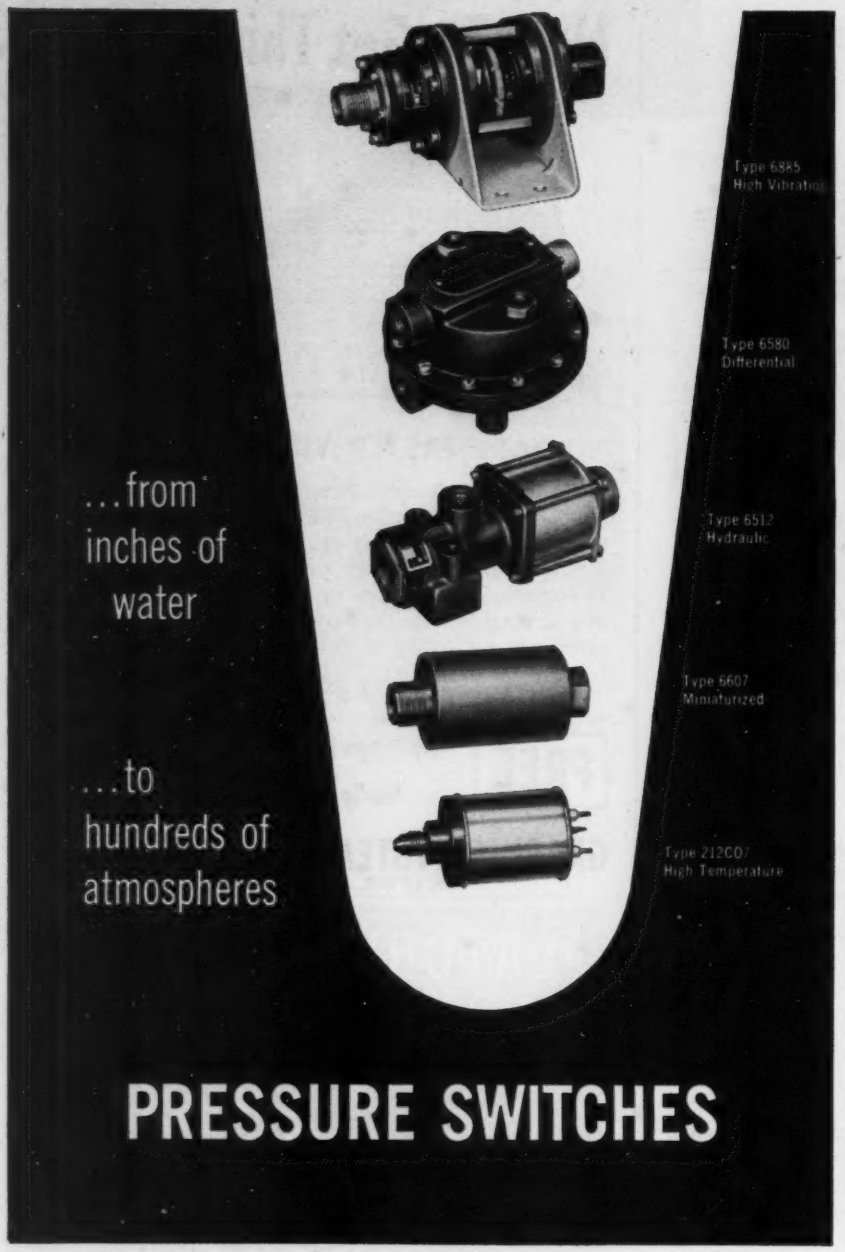

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SYSTEMS DESIGN

Portable Temp. Chamber

Due to the ability to reach temperature extremes quickly in the −100 through +500°F. range, a portable temperature chamber can be used in curing resins for small component encapsulating. The 40 lb. chamber, designed for testing miniaturized components and equipment measures 10 x 24 x 14 inches and has a test volume of 800 cubic inches. The unit can be rapidly cooled to cryogenic levels with either dry ice or liquid CO_2. Delta Design, Inc., San Diego, Calif.

Write No. 515 in Box on Inquiry Card

Walk-in Environmental Chamber

To facilitate environmental testing of large items, American Laboratories Div. of American Electronics, Inc. now has available a second permanent walk-in chamber. This new unit is 12 feet long, 7 feet high, and 10 feet wide, with an 8 foot by 7 foot access door. Testing coverage includes such typical climatic exposures as high temperature (+185°F), low temperature (−90°F soak and −65°F operational), fungus, salt spray, sand and dust, sunshine, rain, and humidity. This new chamber has been designed with both a mechanical refrigeration system and a liquid CO_2 (25 ton) cooling system so that constant −65°F ambient conditions can be maintained with large heat loads. American Laboratories Division, American Electronics, Inc., Fullerton, Cal.

Write No. 516 in Box on Inquiry Card

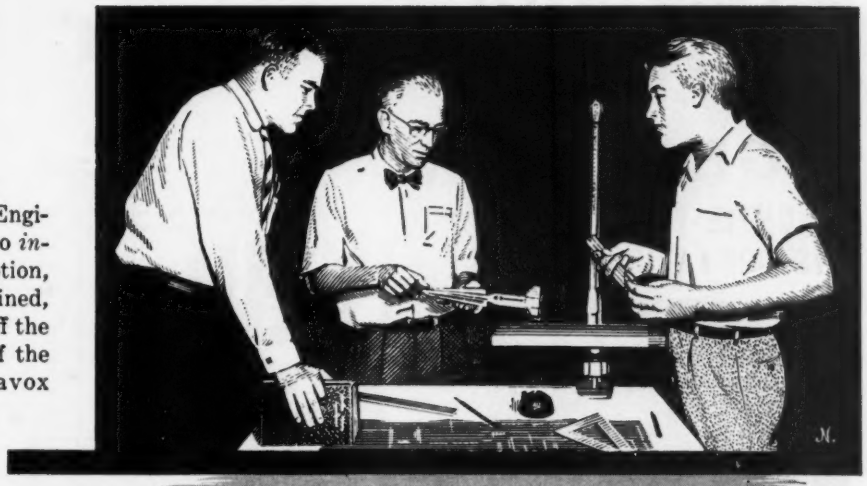
Telemetering System

Totally silicon transistorized tone generating system, capable of operation within associated FM-FM telemetering range, is designed to indicate the precise occurrence and sequence of remote functions through catastrophic environmental extremes. Standard unit contains 11 sine wave oscillators with outputs controlled by means of a remote 28 volt d-c supply through a gated switch. The opening of any gates allows the respective oscillator outputs to appear on the common bus of the summing amplifier where they are mixed. The mixed composite signal is amplified and may then be fed to a transmission line or to a voltage-controlled subcarrier oscillator for conversion to FM within a specified IRIG band. Tone frequencies: 25 cps-100 kcps. Solid State Elect. Co., Van Nuys, Cal.

Write No. 485 on Inquiry Card

Men

who refuse to get lost in the crowd. Engineers with a yen for challenge . . . who *intend* to see their ideas put into motion, These are the special breed of determined, creative, thinking individuals who staff the government and industrial division of the Magnavox Company. And Magnavox needs more people like them . . .



To

fill present openings at the three Magnavox military and industrial plants. In Fort Wayne, Indiana, where families enjoy the good life of a growing Mid-Western community. In Urbana, Illinois, home of the University of Illinois which has one of the largest communications, physics and radar research centers. Or in America's largest electronic community, Los Angeles, California.

Do

engineering to develop advanced anti-submarine warfare systems in conjunction with the Navy Department. Projects on tap for the future offer experiences just as challenging and rewarding—not only in ASW, but in Communications, Missiles, Airborne Radar and Data Processing Equipment as well.

Phone Dick Eary (collect, of course) at Eastbrook 9721 in Fort Wayne or write him for complete information.

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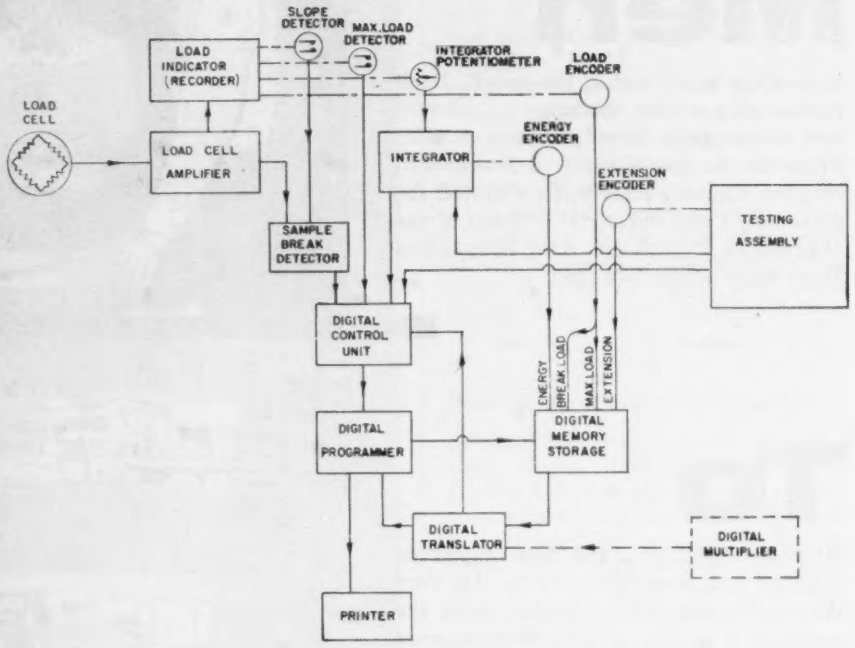
SYSTEMS DESIGN



AUTOMATIC MATERIALS-TESTING SYSTEM

Fast and Accurate Stress and Strain Analysis

In line with the growing demand for automatic readout systems, Instron Engineering Corp., Canton, Mass., has equipped its materials testing machine with a high-speed digital printing system. Characteristics which can be selected for printout include maximum load or stress, breaking load or stress, total extension, energy to break and load at a preset extension or extension at a preset load.

A sample of material is placed in the jaws of the testing assembly and a load is applied. An electrical signal is produced from the load cell which, when amplified, produces a displacement of the load indicator proportional to the stress on the sample. An encoder, which is geared to the movement of the load indicator, follows the load on the specimen. Other encoders mechanically geared to the movements of a pulling jaw and the integrator follow the extension of the sample and the area under the load-extension curve. Each encoder has one or more magnetic memory storage units where information can be held until it is printed in digital form—usually at the completion of the test. Four values can be read out on the printer and a series of tests can be totalized whenever desired. Up to six values can be printed if totalizing is not required.

Total elapsed time from placing the sample in the jaws until the information is printed out is less than 15 seconds for most materials tested. A digital multiplier circuit is available to provide print-out in whatever units are desired. This system can be adapted to many applications and test requirements.

Write No. 156 in Box on Inquiry Card

Miniature Taper-Pin Terminal Blocks

Simple, fast, dependable connections between printed circuits and external wiring can be obtained with a new line of blocks which come in six and ten terminal sizes. These tiny blocks mount upright on printed-wiring boards with solder studs slipped through holes for dip-soldering, while the top receptacles take taper pins for solderless connections. The blocks may be stack-mounted with screws slipped through the end eyeletted holes. The insulation resistance of the block material (glass-fiber-filled Diallyl Phthalate as per mil-1-19833) 5,000,000 megohms remains high—200,000 megohms after 3 hours at 280°F, or 2,000,000 megohms after 30 days at 100% RH. 80F., rising again to 5,000,000 megohms after removing the moisture film. The blocks have a working voltage of 11,000 rms (1550 dc) at sea level. Descriptive literature available from Kulka Electric Corp., Mount Vernon, New York.

Write No. 200 in Box on Inquiry Card

Magnetic Tape System With Delay

Mobile loop delay and reel storage magnetic tape system continuously monitors and records analog data. The system, designed for field use, consists of a continuous loop tape transport, a reel-type transport, a master control unit, and a power supply. No unit weighs more than 75 pounds.

The loop transport control unit operates both the loop and reel transports. The loop stores 30 seconds of data before passing over "reproduce," "erase," and "record" heads successively. When the operator wishes to preserve data, he switches to the reel transport during the 30-second storage time. The data on the loop and subsequent data are transmitted to the reel transport for permanent storage.

Output of the reel-type transport can be transmitted at 600 ohms over telephone transmission lines, or can be switched to 100-ohm output. Electronic "pulse stretchers" in the loop transport shape the input pulses into a form that can be transmitted by telephone lines, and whose shape is easily analyzed.

The reel transport records two tracks on quarter-inch-wide magnetic tape at 7½ inches per second. Pulse data from the loop transport and voice data from the operator can be recorded simultaneously.

A new feature in both transports tensions the tape slightly as it passes over the heads. This reduces flutter to 0.25% rms maximum. When the reel transport is in "fast forward," or "rewind" position, sapphire bearings lift the tape above the all-metal heads to prevent wear.

Airborne-type plug-in record and reproduce amplifiers minimize size and weight of both transports. The system was built to military environmental specifications. Consolidated Electrodynamics Corp., Pasadena, Cal.

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Mobile Chamber

A new mobile environmental chamber with a range from −125°F to +350°F has exclusive entrance ports at the door for instrument cables eliminating the usual inconvenient feed-through ports and terminal panels. Temperatures can be lowered from +350°F to −100°F in fifty minutes, and raised from −100°F +350°F in 30 minutes. Accuracy is ±2°F. Features include a 24-hour recording chart, interior lighting, multi-pane thermal glass assembly in the door, hermetically sealed heating elements, special safety controls and a stainless steel interior. Power requirements are 220 volts, single phase, 60 cycle; or 220 or 440 volts, 3 phase. Webber Manufacturing Co., Inc., Indianapolis, Indiana.

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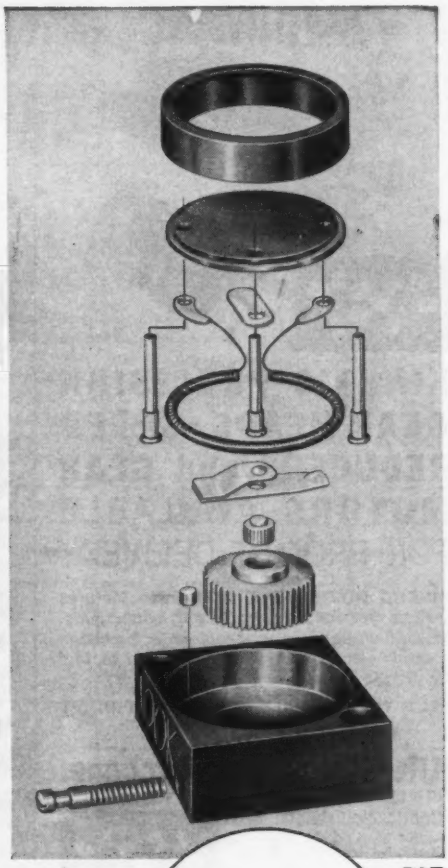

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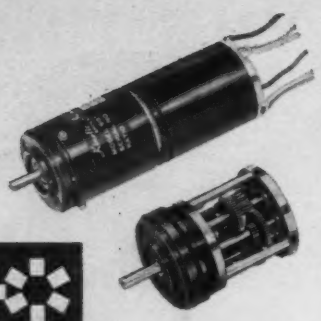

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SYSTEMS DESIGN

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Calculator permits rapid solution of servo problems without lengthy calculations. It can be used by experienced engineers to design and evaluate closed loop feedback systems such as servo drives, feedback amplifiers, power supplies and radar loops. Typical problems solved rapidly include: is the system stable; effect of gain change on stability; determination of velocity and acceleration constants: gain and phase margins; choice of lead-lag networks to stabilize system (including use of complex roots). Calculator plus plotting pater—$4.50.

Source: Control Aids, Inc.
P. O Box 207
Woodmere, L.I., N.Y.—Dept. 48

Heat and Corrosion-Resistant Castings

64 page booklet is designed as an aid to those interested in stainless steel and high-alloy casting selection, design and production. These alloys are used under the most severe corrosive conditions and with temperatures up to 2000° F. and higher. Typical headings include; How To Select the Proper Casting Alloys, High-Temperature Mechanical Properties, Heat-Resistant Alloy Casting Design, Corrosive Attack, Groups of Corrosion-Resistant Alloy Castings, Corrosion Data, Machining and Welding. This material is supplemented by thirteen tables on heat and corrosion-resistant castings. Readers Service Section of The International Nickel Co., Inc., New York 5, N.Y.

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O-Rings

24-page design and data handbook on the use of O-rings as high temperature seals contains test information on 150 fluids and gases to which the O-rings are compatible; recommended O-ring and groove design techniques; information on three O-ring compounds and dimensions and other data and standard sand specials. Parker Seal Co., Culver City, Calif.

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Synchros

16-page catalog contains definitions of synchro parameters, dimensional drawings, circuit diagrams, and physical, electrical and mechanical characteristics of size 8, 10, 11 and 15 synchros for military, industrial and scientific applications.

Source: John Oster Manufacturing Co.
Racine, Wisconsin

For your copy: Write No. 492 in Box on Inquiry Card.

Permanent Magnets

Described are the special properties, uses and applications of Indox I and V ceramic permanent magnets. Typical and minimum characteristics are graphed and summarized. Handy magnet selector chart, list of stock magnets and a de-rating curve for low temperature operation are included. Magnetic, material temperature characteristics and demagnetization curves on Indox VI are also given. Ind. Steel Prod., Div. of Ind. Gen. Corp., Valparaiso, Ind.

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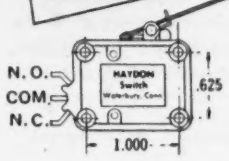
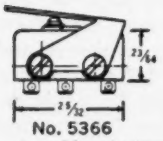
HAYDON Switches and Actuators for Military and Industrial Applications



SERIES 5200 PLASTIC SNAP-ACTION SWITCHES

19 Models available with button in center position (5219), or with button in off-center position (5222) as shown at left with integral actuator. Terminals: Solder hold or taper tab feature. Meets snap-action switch specification MIL-S-6743 and vibration requirements of MIL-E-5272A, Procedure II.

SPECIFICATIONS TABLE	5219	5222
Contact Gap, min.	.030	010
Operating Force	6-10 oz.	20-27 grams
Release Force, min.	3 oz.	12 grams
Differential Travel, max.	.015	030
Pretravel	.031	040
Overtravel, min.	.025	.050
Electrical Ratings, 30 Volts DC, 115 Volts AC	10 amps. Resistive 5 amps. Inductive	5 amps. Resistive 3 amps. Inductive
Ambient Temperature Range	−65° +300°F	−65° +300°F



No. 5366 with actuator

Integral actuator

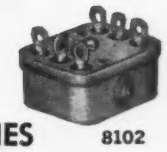
SERIES 5300 SUBMINIATURE SNAP-ACTION SWITCHES

The basic 5300 switch meets the requirements of MS 25085, is available with a full range of operating forces from 2 to 20 ounces, and the case is made of Diallyl Phthalate. Versions with special characteristics and with integral roller and leaf actuators are available. Catalog information describes auxiliary actuators.

SPECIFICATIONS TABLE	5366	53114
Operating Force, max.	5 oz	20 oz.
Release Force, min.	1 oz.	4 oz
Differential Travel, max.	.004	.004
Overtravel, min.	.005	.005
Electrical Ratings, 30 Volts DC, 115 Volts AC	10 amps, Resistive 8 amps, Inductive	10 amps, Resistive 8 amps, Inductive
Ambient Temperature Range	−65° +300°F	−65° +300°F

7102

HAYDON HERMETICALLY SEALED SWITCHES


8102

6107

The standard, one piece heavy duty beryllium copper switch blade with fine silver contacts maintains contact without chatter, during shock and vibration, as required in military specifications such as MIL-E-5272. At Haydon Switch, a complete custom built design and development service is available to solve your problems in hermetically sealed switches and suitable actuators.

SPECIFICATIONS TABLE		6107	7102	8102
Contact Gap	IN.	.015	.020	.030
Operating Force, Max.	OZ.	22	32	64
Release Force, Min.	OZ.	6	6	8
Differential Travel	IN.	.0005-.005	.001-.006	.003-.015
Overtravel, Min. Available (In Use Do Not Exceed)	IN.	.007	.005	.010
28 Volts DC, 110 Volts AC (Amps Resistive)		5	10	25
28 Volts DC, 110 Volts AC (Amps Inductive)		3	4	8
Life at Rated Load (Actuations)		100,000	100,000	100,000
Ambient Temperature Range	°F	−65 +300	−65 +300	−65 +300
Altitude	FT.	0-80,000	0-80,000	0-80,000

TOGGLE-ACTUATED AND PUSHBUTTON SWITCHES

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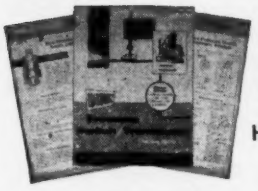
1500 Externally Adjustable Pressure Switch (6 oz., 3⅜" × 1 5/16")

1580 Miniature Gage and 1880 Miniature Absolute (4 oz., 3" × 1½")

1590 Subminiature Gage (2½ oz., 3" × 0.937")

1890 Subminiature Absolute (2½ oz., 2¼" × 0.875")

1700 Series Externally Adjustable Barometric Pressure Switch (4 oz., 2¼" × 2¼")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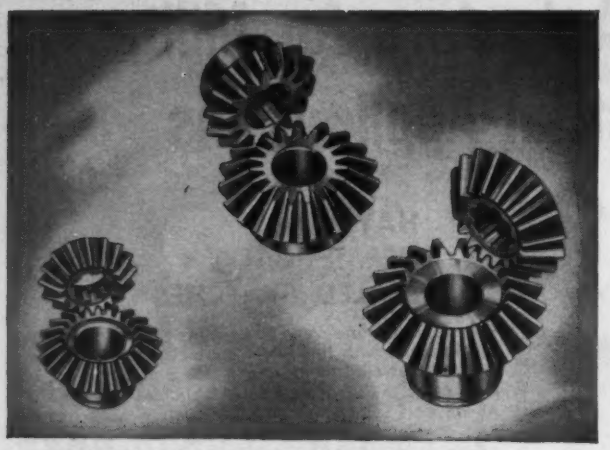
FOR PRESSURE SWITCHES CIRCLE NO. 46 ON INQUIRY CARD

FOR HERMETICALLY SEALED SWITCHES CIRCLE NO. 47 ON INQUIRY CARD
FOR TOGGLE AND PUSH-BUTTON SWITCHES CIRCLE NO. 48 ON INQUIRY CARD



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WORTH FILING

Metal Impact Forming

Full potential of the aluminum extrusion process is explored in a 34-page booklet. It outlines design possibilities, tolerances, size ranges, and applications of impacts.

Source: Alcoa Company of America
Pittsburgh, Pa.
For your copy: Write No. 493 in Box on Inquiry Card.

Aluminum Bronze Alloys

Chemical and physical properties of nine major grades and heat-treated variations of aluminum bronze alloys are described in a 20-page bulletin. The closely controlled chemical limits are shown and recommended applications for each grade are listed. The alloys possess high resistance to metal-to-metal wear, abrasion, fatigue and corrosion and they are non-magnetic and non-sparking.

Source: Ampco Metal, Inc.
Milwaukee, Wisconsin
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Plastic Electronic Components

24-page catalog outlines specific mechanical and electrical design and environmental characteristics of plastic electronic components. Items include: metal base stand-off and feed-through insulators; compression mounted, miniature, nine-pin tube base connectors; test points; miniature and sub-miniature sockets; copper clad Teflon for printed circuits; spaghetti tubing and grommets. For convenience, the catalog also contains several basic engineering drawings of stand-off and feed-through insulators drawn on tracing paper and designed to simplify and expedite presentation of data when requesting product information.

Source: Garlock Packing Company
Camden, New Jersey
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Semiconductors

An 8-page newsletter contains a 4-page article entitled "Properties of Semiconductor Devices Affecting Voltage Division", in which voltage distribution and various methods to achieve equality are discussed, analyzed, and recommendations made for the solution of specific problems.

El Segundo, California
Source: International Rectifier Corp.
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Silicon Fluids

A handy design file, with charts, is believed to be one of the most thorough, useful compilations of the mechanical properties of silicone fluids yet published. It is not meant to be simply a reference guide, but a working tool. Some of the graphs are on 17 by 11 inch sheets so that a designer can work right on them. Additional copies of any sheets may be obtained on request. The file includes materials not available elsewhere on the viscosity-shear relationship of dimethyl oils at shear rates above 10,000 reciprocal seconds. Six whole sheets are devoted to the effects of silicone fluids on elastomers, including information on modifying silicone fluids with plasticizers to give increased rubber swell, which facilitates sealing of the fluid with elastomeric seals. It frankly tells when not to use, as well as when to use silicone oils for a given application.

Source: Union Carbide Corporation
New York, New York
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Superalloys

"Superalloys by Vacuum Induction Melting", a new 36 page book, in addition to a complete description of the process itself, discusses present and future applications of superalloys. Property charts show the outstanding characteristics of alloys produced by the vacuum induction process as compared to conventional high temperature alloys.

Source: Metals Div.-Kelsey-Hayes Co.
New Hartford, N. Y.
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Socket Screws

82-page technical reference on industrial socket screws, believed to be the most complete ever compiled, includes both standard catalog data and extensive design and performance information. Three distinct sections cover: basic information on size, material and availability; 33-page section of basic design and performance information, including such items as recommended tightening torques, shear and tensile values, mechanical properties and hardnesses; a simplified technology of fasteners, including principles and practices of screw thread plating, proper gaging techniques, function and application of self-locking screws, fastener fit and how to diagnose misfits and sections on miniaturization and reliability engineering as design trends.

Source: Standard Pressed Steel Company
Jenkintown, Pennsylvania
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Instrument Gears

Reference handbook on instrument gears provides precalculated gear data and dimensions in useful table form. Diametral pitches of 64, 72, 80, 96, 120, 160, 180 and 200 for 20-degree pressure angle spur gears were selected on the basis of most frequent use in the instrument and servo control industries. Extra fine pitch sizes permit handbook use when designing for miniaturization.

Source: Babcock Relays, Inc.
Costa Mesa, California
For your copy: Write No. 500 in Box on Inquiry Card

Tubing and Couplings

40 pages of design information on aircraft and missile tubing and duct joints are suitable for a wide range of temperatures and pressures for gaseous, liquid and air systems, as well as couplings for any fastening and sealing applications.

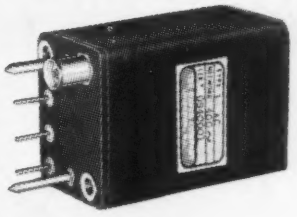
Source: Aeroquip Corp.
Los Angeles, California
For your copy: Write No. 501 in Box on Inquiry Card

WORTH BUYING

Thermistors and Varistors

New data book covers thermistors and varistors, thermal conductivity cells, electronic controls and thermal, electronic and physical-sensing devices. Included are R vs. T curves and E vs. I curves. The new edition offers engineers sufficient information in order to evaluate the needs in their own activities for thermistors, varistors and allied devices. Price $1.00.

Source: Victory Engineering Corp.
580 Springfield Road
Union, N. J.



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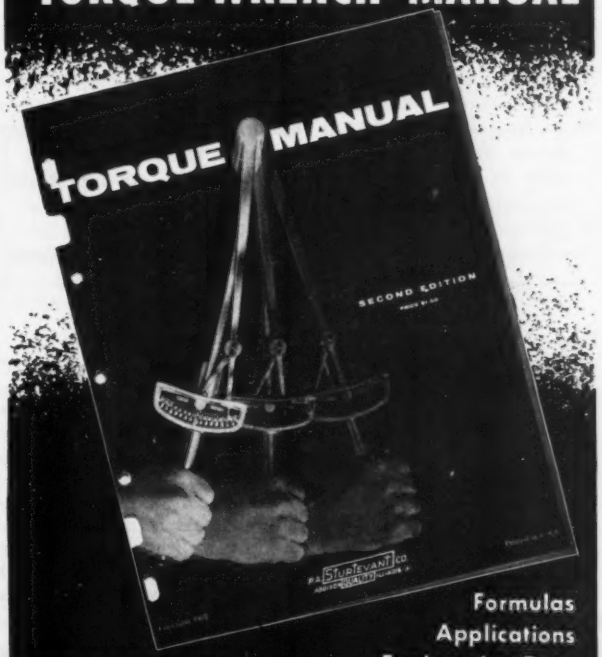
"TORQUE WRENCH" MANUAL



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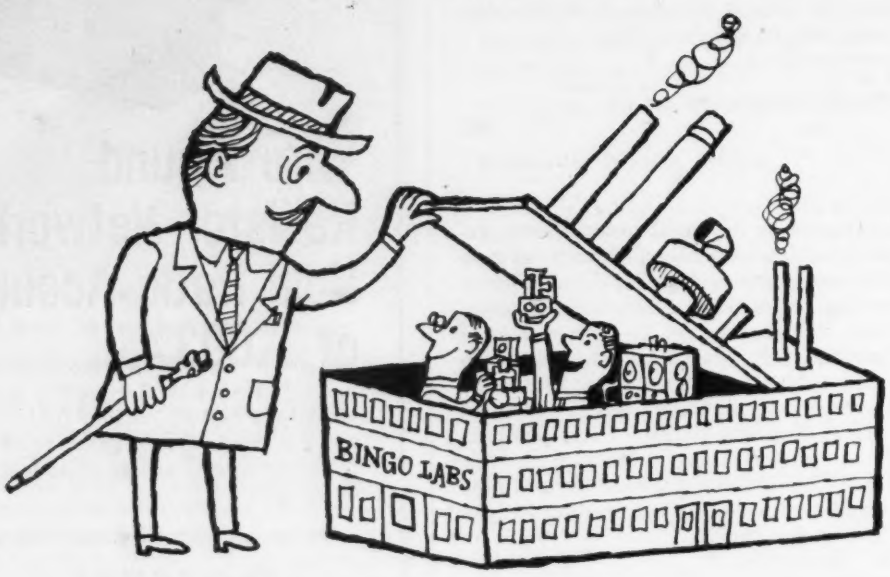

WALL STREET IS WATCHING YOU

By George Edgar

Research Department, Carl M. Loeb, Rhoades & Co.

Electromechanical designers are mature engineers; and mature engineers are continually confronting themselves with these problems, among others:

- *Is this the time to strike out for myself; and if so, how can I finance my efforts?*
- *Perhaps I should stay in my current position and simply invest my available funds on the market; if so, am I able to evaluate those companies with good products and bright management?*
- *Should I be doing both?*

For those engineers who have considered these problems, we present one authority's opinion on investments in electronic and electromechanical organizations. Mr. Edgar's comments, presented here, were originally organized last April. But the philosophy presented, according to Mr. Edgar, remains valid while specific choices within this philosophy can vary from day to day, depending upon external conditions. Mr. Edgar, an investment authority, has concentrated his efforts for the past ten years in assist ing established companies and creating new ones within the electronic and electromechanical industries.

A recent issue of *Newsweek*, devoted to the decade of the 60's, notes that there are 2 fundamental, dynamic forces in our economy. The first is the predictable growth of population; there will be 30 million new Americans over the next 10 years. The 2nd major force is the upgrading of consumer tastes. This upgrading, in the words of Sam Stedman [Loeb, Rhoades partner Samuel L. Stedman, described in Feb. *Fortune* as one of the 10 most influential men on Wall Street], means that there will be more people with more money to spend in more leisure time. As a result, where will they spend their money? They will spend it on the true growth industries: health, recreation, convenience and education.

The securities in these true growth categories are well known to you. They are the Polaroids, the Brunswick-Balkes, selected drugs such as Rexall, the Crowell-Colliers, the Grolier Societies, Diner's Club, Avon Products, and so forth. The area I am concerned with in this talk is new technology, which is also one of the truly valid growth areas.

But first, a few general comments about the stock market are in order.

It's a generally high market

There are differences of opinion at Carl M. Loeb, Rhoades, as there are in any investment firm. But, generally, we regard this market as being high. However, we argue that there is no such thing as a stock market. We have a market of stocks. Since we are in the business of selling securities, what we must do against this general background of high security prices is guide our clients into those issues that are relatively attractive.

Mr. Stedman's philosophy, as you well know, has always been emphasis on growth . . . true growth. There are 3 other ways of making money in the market: (1) Buying cyclical stocks at the right point in the cycle; (2) buying companies which are in the process of being rehabilitated; and (3) buying an undervalued, overlooked stock that eventually will be recognized by the market. Each approach has its merits and its followers. However, Mr. Stedman and I are oriented more to growth because you can be wrong in your timing, but if you stay with a growth stock you will be right sooner and realize more profit in the long run.

Vindication of this thesis was seen in the recent sharp decline in Polaroid and other growth stocks as the result of Mr. Khrush-

chev's visit. You saw how quickly they recovered and went on to make new highs.

In a nutshell, over the long run we are bullish on consumer spending, we are bullish on inflation, and we are bullish on advanced technology. Now we come to the area of electronics.

Please consider these remarks very seriously. There are gross misconceptions about electronics in the investment community and, as a result, gross excesses are taking place in the market. People are going to be hurt again, as they were during the uranium bubble. To avoid these misconceptions and pitfalls, and to be able to recognize the correct road to investment success in "electronics," I shall offer a new concept, a new approach, a new method.

$10 radios and $2,000,000 computers

I will start by saying there is no such thing as an electronics industry. It is a myth. This is why: The engineer will tell you that electronics is any product built around a vacuum tube or its equivalent semiconductor device, such as a transistor. Using this definition, they say that electronics is a $15-billion industry, that it is attractive, that it is dynamic. From the investment viewpoint, I say nonsense! This is not so!

If you look at this industry, you will see that it includes $10 radios and $2 million computers. How can you compare them? It includes 40c receiving tubes and $10,000 microwave klystron tubes. It includes a company making a simple widget that goes on an obsolete bazooka. It will also, in the same category, include a highly sophisticated scientific group developing a new means of global communication using satellite relays. It includes radio and TV. Now we all know that radio and TV, as a business, is no different from refrigerators and waffle irons. Is there anything dynamic about it? Is there anything dynamic about receiving tubes? Is there anything dynamic about 2c capacitors that go into portable radios? Obviously not. So, you see, the electronics industry, according to the classical definition, includes large areas of business activity that are mundane and that are centainly un-dynamic.

What, then, are we looking for? I believe we are seeking growth. Growth comes from new products that create new markets. New products come from the discoveries of applied science.

I believe you want to invest in the frontiers of science because it is science that is the basis of automation, it is the arena of our conflict with Russia, it will be the mainspring of the tremendous future upheaval in our standard of living. So never again think in terms of electronics. Think only in terms of applied science.

There are many applied sciences. An example of a specific area of applied science is drugs. In the future when you think of space-age stocks and electronics stocks, I would ask you to use the analogy of the drug industry because the drug industry is based upon specific sciences, such as biology and chemistry, out of which come new products. In drugs you are not investing in products; you are investing in the brain power that can create the products. The same is true of all applied sciences.

Other examples of applied science are metallurgy, new concepts of photography, chemistry, optics, and physics. I am not competent to discuss all of these with you, but I can discuss photography and physics, so I will confine myself to these specific areas.

The new approach that you will hear today has 3 clear-cut steps: The first is to select the specific technologies that are attractive, which I will enumerate later. The 2nd is to select those companies that give you maximum exposure to the specific attractive technologies. The 3rd aspect to this new approach is to consider the equity base (price times number of shares) and, other things equal, to favor the company with the smaller base. This is one of the most important concepts in our new method.

This overall new approach should not be considered the Golden Rule—there are many fine companies that will not qualify, such as IBM because of its large size, or RCA because of its widespread activities. In addition there are companies that make relatively mundane products but which have superlative managements. Therefore, treat this new approach only as a guide.

Virtue of small companies

While the greater potential lies in the smaller equity base, this does not mean that you indiscriminately should concentrate on small companies. Obviously the requirements of your customers must be recognized. A large company giving good exposure to a specific, attractive technology would be suitable for institutional and conservative clients. But, for the businessman and the intelligent speculator, a package of small companies usually is more desirable.

These, then, are the 3 steps to the new approach. I will be specific later.

There are 2 other broad considerations. They are that, as a general rule, the consumer market for scientific products is unattractive. There are certain exceptions, such as the drugs, and one great exception—Polaroid Corp. It is a great exception because Polaroid is one of the few companies that has a basic patent position.

The 2nd general rule is that it is better to invest in the basic component than in the end system. This is very important, so let me explain what I mean.

We all want to invest in missiles. We all know many missiles are being developed. But we can never be sure which one will finally go up. We are never sure which missile will be canceled, which will go ahead. But we do know one thing: No matter what missile goes up, it will use transistors, diodes, rectifiers, magnetic amplifiers, exotic fuels, new metals, complex test and tracking equipment, and so on. These are the basic building-blocks for any missile system. Therefore, we prefer to concentrate on basic components.

In other words, buying a basic, sophisticated component to take advantage of all of the exciting things happening in hundreds of new types of end equipments and systems is like buying the oil industry through Halliburton Oil Well Cementing. You cover the waterfront with one investment vehicle.

How science investing differs

In dealing with science we must change many of our classical investment rules because they simply do not apply. For example, the real asset of a good science company is brain power. So what difference does it make if it has a low book value? Therefore, one of the classical concepts that you must reject is slavish emphasis on book value.

Another problem in dealing with good science stocks is that they grow rapidly and have long-term validity, yet most investors—for some strange reason—feel compelled to sell on a double. When you find a good technical company, sound advice is to ride with it all the way. How many customers have come to you and cried bitter tears that they could have been rich if they had bought IBM 10 years ago? The truth of the matter is that they would have sold it out 10 times over. It is possible when you are dealing with true, dynamic growth to shoot for the 500% and 1,000% marks. So don't sell out on the first double.

Another classical predilection that we must dismiss is that of the dividend. A company that is growing fast cannot afford to pay significant cash dividends. The appearance of a significant cash dividend is often the sign of an unattractive stock.

Then there is the problem of the listed versus the unlisted. Our clients love listed stocks. They like to see the prices dance on the tape or quoted in the daily newspapers. But, dynamic appreciation only too often occurs when a company graduates from the unlisted to the listed market. We, and our customers, must be aware of the great values and potentials that are among unlisted companies.

Another popular prejudice is the preference for large companies. Other things being equal, the small company in the right field, with the right management, will turn in much better investment results. Therefore, don't disregard small companies. A corollary of this, of course, is the known versus the unknown. Everybody likes to play a favorite which by definition already reflects an enthusiasm that probably has caused the price-earnings multiple to expand from 10 to 30 times earnings. You all know that we can make as much or more money from the recognition of a stock—as the complexion of its investment acceptance changes from white chip to red chip to blue chip—as from the growth of the company itself. Therefore, don't be biased against unknown companies.

Attitude toward high climbers

Investors have another problem in their reluctance to buy a stock that has risen sharply or which is selling at a historical high. Any time in the past 5 years when you bought Ampex it probably was selling at a historical high. But we still find people who say: "My goodness, look where the stock came from! How can you expect me to buy it now?" The important thing to consider is future potential, not history.

Another pitfall is the investor's penchant for diversified companies. There is nothing wrong with a specialized company, provided it is in an interesting area of specialization. For example, Ampex, Electronic Associates, and High Voltage Engineering are specialized companies. The correct application of our new method will often find us dealing with specialized companies. We can achieve diversification by buying a package of specialized companies.

Now that we have covered many generalities, we will get down to brass tacks.

I am going to discuss certain specific technologies that I think are attractive and suggest, to some extent, that you mold your thinking and investment program along these lines.

In the course of this discussion the names of many companies will be mentioned. However, this will be for illustrative purposes. I don't consider all of the companies attractive and in some cases I will so indicate. On the other hand there are many companies that qualify under our new formula, such as Haloid, which will not be mentioned because of time limitation. Keep in mind that it is a new philosophy that is being advocated here.

The first basic technology I recommend is solid-state physics. You all know what solid-state physics is, but you are not aware of it. A product of solid-state physics is the transistor. The trouble with most investors is that they think of the transistor as being an industry in itself. Solid-state physics (remember the analogy to drugs) is the science that created the transistor of which there are hundreds of different types. It also created diodes and rectifiers. In the future, it will give us tunnel diodes, thermoelectric generators, electronic refrigeration and electroluminescence (which means wall panels of built-in light).

Newsweek discusses something quite dramatic: thermoelectricity (the direct conversion of heat into electricity). This is also the principle of electronic refrigeration. These are things of the future. They will be tremendous new industries that will emerge out of solid-state physics. Therefore, you should not rush to the phone to sell your "transistor" stocks because a tunnel diode was discovered that is going to "replace transistors." The company that has solid-state physics technology will make the transistor . . . it will make the tunnel diode . . . some day it will make thermoelectric elements . . . and . . . some day it will make components for electronic refrigerators.

Solid-state physics is one of the basic new industries of our age. From a commercial viewpoint, it was born only 5 years ago. It started with about $35 million of sales in 1955. This year sales will be about $350 million. I think sales will reach $1 billion over the next 5 to 7 years in only those products presently being produced or soon to be introduced.

The interesting thing about scientific developments is that usually they do not replace anything. You heard that the transistor would replace the vacuum receiving tube. Vacuum-tube sales will be higher this year than they have ever been in the past, principally because the market for industrial and specialty tubes is growing rapidly. By the same token I believe that when the tunnel diode becomes a commercial product in three years, transistor sales will still continue to rise. Basic technologies create products that never were possible with the old products. Computers that we use today could not have been designed around vacuum tubes. So the new products of science generally do not replace anything. They primarily create new markets. This is the essence of growth.

A curious thing about solid-state physics, and the other technologies that we will mention, is that when you count the number of companies that provide meaningful investment exposure, you find a frighteningly small number of eligible vehicles.

For example, we think solid-state physics is an attractive business, and it is. Now RCA makes transistors and so does Texas Instruments. Two years ago when you bought Texas Instruments, you bought more transistors in every dollar of investment than you did in RCA simply because RCA also made a lot of radios and TV sets and things that had nothing to do with transistors. Other things being equal, therefore, Texas Instruments gave you better exposure to that specific development.

There are only 6 established companies that really give you meaningful exposure to solid-state physics. General Electric is a big producer of semiconductor devices (the term "semiconductor" is synonymous with solid-state physics), but you don't get enough of it in GE. The same is true of Westinghouse, Raytheon, RCA, Hoffman, Clevite, and so on.

Half-dozen in solid-state

The 6 meaningful investment vehicles in solid-state physics, in their order of size (equity base), are Texas Instruments, Transitron, Philco, Fairchild Camera, International Rectifier, and General Transistor.

Among these 6 you will find a stock for every appetite—from the conservative investor to the enterprising businessman and the intelligent speculator. Now let us look at this list of companies.

The first startling aspect about this list is the wide range of values that the companies command in the market—that is, their market price times the total number of shares outstanding. The present market values of these companies are, roughly: Texas Instruments $700 million, Transitron $350 million, Philco $150 million, Fairchild Camera $140 million, International Rectifier $30 million and General Transistor $22 million. Immediately we can see that the investment-grade issues will be at the higher end of the size ladder, because safety generally increases with larger size, while the speculations with greater potential will be at the lower end. After all, other things being equal, it is easier for a $22-million or a $30-million company to double in value than it is for a $700-million or $350-million company.

The second important statistic to consider is the total volume of business done by each company and the percentage that comes from semiconductors. Texas Instruments, whose revenues are approaching $250 million, finds only about 30% of its sales in the semiconductor area. By the end of 1960, Fairchild Camera will have about 50% of its projected $65-million volume in semiconductors. International Rectifier, whose sales are approaching $15 million, finds about 60% of its business in semiconductors. Philco will have a much smaller ratio, but I would like to discuss this company later on as a special situation. Transitron, doing a business of $50 million, and General Transistor, with sales currently at the rate of about $12 million, are the only 2 in the list whose business is virtually entirely devoted to semiconductors.

Therefore we not only find great differences in market size and dollar volume, but the relative proportion of semiconductor sales differs widely. Both factors are key in determining the quality of the investment, ranging from blue chip to intelligent speculation, and the degree of exposure to solid-state physics.

This type of analysis is essential in all of the other specific technologies.

My choices for investment-grade issues, where we must give up some dynamism in order to maximize safety, are Texas Instruments and Transitron, in that order. The semi-investment or red-chip issues are Fairchild Camera which, size for size, probably has the best technical group in the industry, International Rectifier and Philco. The enterprising speculation is General Transistor.

Strictly speaking, not all of these companies are directly competitive. There are many different aspects to the semiconductor industry. There are signal devices and power devices. There are germanium and silicon devices; grown junction, acid-etch and diffused devices, and so on. Semiconductor products are not like light bulbs that you take out of one socket and put into another. They are very unique gadgets. No company makes all of these products. Also, the art has so much room for advancement that widespread, early standardization is unlikely. Therefore, don't pay too much attention to the problem of competition for the next few years. Also don't worry about price reductions because in the industrial and military market such price reductions are actually "bullish" and not "bearish," because they pass on to the customer the savings of improved technology and higher yields, thus broadening the market.

Market for passive components

The next area that is attractive is passive components. Semiconductor devices such as transistors or diodes are active components; they *do* something. These active devices in electronic circuits need associated passive components, such as capacitors, that *control something*. The new active devices have created a market for new passive devices. The leading company in new passive components is Sprague Electric. It is a blue chip that has broken out of its 5-year plateau. I consider the stock cheap. In addition to making advanced passive devices, it is developing a semiconductor business under Philco license.

A valid speculation in passive components is Aerovox.

The 3rd attractive technology is microwave. In the *Newsweek* article referred to previously, Dr. Stephens of Stanford Research Institute was quoted as saying that the '60s would be the decade of microwave.

Microwave is not a specific equipment. It is not radar. It is not a relay station. It is a section of the radio spectrum that starts where TV leaves off and ends where infrared begins. It is high frequency, and high frequency has certain properties that make it useful in a broad range of different applications, as, for example, missile guidance, computers, radar, satellites, telemetry, tropospheric communications, and even electronic cooking. These are all specific applications that come out of the basic technology of microwave.

I told you before that we prefer to stress components. We tend to avoid the systems company. In microwave technology, we have a very convenient component. It is the microwave tube. It's hard to make and there are only 2 companies that give you meaningful exposure to it. They are Varian Associates and Eitel-McCullough. These are not the only 2 companies in the industry. Bendix makes microwave tubes; so do RCA, GE, Raytheon, Westinghouse, Sperry Rand and Litton. However, you get the most exposure to microwave tubes per dollar of investment from Varian and Eitel-McCullough.

Because of its larger size, broader technical base and longer seasoning, Varian is the investment-grade issue. Eitel-McCullough, which is somewhat statistically cheaper but more speculative, is the semi-investment grade issue.

There is another area of microwave that is attractive—microwave instruments and test equipment. Here again, you find a very small number of eligible companies. They are Hewlett

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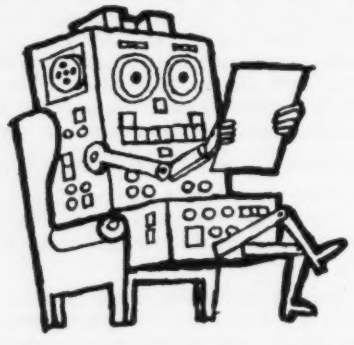
Packard, the giant and blue chip of the microwave instrument industry, and Polarad (not Polaroid), and FXR, which particularly appeal to me. Another excellent company is Electro Instruments. And the last in that small group is Microwave Associates.

In the areas of new "electronic" metals, there are only 2 companies: Fansteel Metallurgical and Kawecki Chemical. This is why Kawecki has been so active and strong lately. It has few shares, a small equity base, giving you maximum exposure to new metals, particularly tantalum. Tantalum is growing parallel with semiconductors because they are used together. They are "kissing cousins." Kawecki is by far the most interesting speculation.

In the field of data processing, you have giants such as IBM and National Cash Register. I am not very interested in that group because the companies are so large. I don't mean to say that I would sell IBM out of a portfolio. It is a magnificent company. However, even among the giants we find 2 small companies that have unique positions and that merit a place in a representative science portfolio. They are Control Data Corp., which probably has the most advanced large-scale computer on the market today, bar none, and Electronic Associates which, though catering to the analog computer field, has captured 65% of the market.

There is another area of the data processing industry of which most people are unaware—data preparation or data handling. Our computers calculate with the speed of light, but we bring information to them on ox-carts, meaning that we hire batteries of girls, looking at original invoices, who manually prepare punched cards. This is the bottleneck. Therefore, this is the area to investigate. Data handling, as a market, some day will be as large as data processing, which currently is about $750 million annually. The companies in this field that attract me are Friden Calculators, Farrington Mfg., and General Time. Two specialties that should not be bought indiscriminately, because they are very small and speculative, should appeal to the man who can take the risk. They are Soroban Engineering and Digitronics.



Exciting development at Farrington

Let me extract one company from this list—Farrington. Farrington makes a machine that reads! It will optically read an invoice or page of text and reduce it to computer language. The Air Force has a Farrington machine that reads technical Russian literature. It is hooked into an IBM computer and out comes the equivalent English. The Post Office has a Farrington machine that reads the addresses on your mail and routes letters automatically. American Telephone has several Farrington machines that prepare and read your dividend checks. Other blue chip users include *Reader's Digest*, National Biscuit, First National City Bank, Bankers Trust, Standard Oil of California, and Standard Oil of Indiana. Not bad for a beginning, eh? This is one of the most exciting new developments in office automation and this company may have a monopoly position. Potentially, it has a bigger market 5 years from now than Ampex had 5 years ago. It is a risky stock. It sells in the market for about $40 million and has only about 30 installations in the field. It will report a deficit in 1959, due primarily to heavy expenses for research and development, the establishment of a nationwide sales and service organization, and depreciation on rental equipment; it may break even this year. But think of the potential 5 years from now if this company has one-half of the market in automatic reading equipment! This market probably exceeds 15,000 machines at a yearly rental of

$20,000 each plus another $50,000 per machine in related income from credit cards, embossing services and point-of-sale imprinters.

There is a new specialized area of data processing called information technology. Modern society faces greater danger from being buried under a mountain of red tape than it does from the radiation of strontium 90. We solved only one-half of the data processing problem with our electronic business computers, insofar as they only handle arithmetic. But there is another aspect of paper work that these computers cannot control; that is the actual original document, such as a letter, engineering drawing, photograph, map, etc. We have not yet perfected a way to process automatically this kind of "graphic" information. But we will, and when we do, a new industry will arise that is called information technology.

Billion-dollar information-technology

Huge industrial corporations find that they design the same machine as many as 6 times a year, simply because they do not know that it has already been designed somewhere in another of their plants and the forgotten blueprints are gathering dust in the files. In the future, such companies will punch the parameters of a machine, such as a transformer, into this computer and out will come microfilm with the complete engineering drawings. This is one of the most important new industries. IBM is working on it and so are RCA, Thompson Ramo, Eastman Kodak, Magnavox and Itek. But Itek gives you maximum exposure because the bulk of that company's future activities will be in this new industry which will not enter a commercial phase for 3-5 years. But information technology will be a billion-dollar industry in the future. Itek has been financed by the Rockefellers and it has one of the most outstanding technical groups in the field. It represents a brilliant long-term speculation.

Photography is an applied science, and here we find our dear Polaroid. There is no need to elaborate further on this magnificent growth company. With less than 2 million 60-second cameras in use, and color, small cameras and industrial applications still to come, the surface has hardly been scratched. We consider Polaroid one of the great 10-year growth stocks.

Again in *Newsweek* you have read that the housewife of the future will wash her dishes and clothes with silent sound, or ultrasonics. Ultrasonics is a specific technology and only 3 companies give you maximum exposure to it: Acoustica Associates, Branson, and Narda Ultrasonics. I prefer Acoustica, but Branson is also valid.

Another specific technology that should interest the enterprising investor is infrared. Infrared begins where microwave leaves off and ends where visible light begins. It will have tremendous future application in the laboratory for analytical instruments, in the industrial plant for process control, along railroad tracks to spot hot boxes as trains pass by, and for space communication and anti-missile systems. Three small companies provide meaningful access—Barnes Engineering, Servo Corp. of America, and Infrared Industries. My clear choice is Barnes. It has a little over 300,000 shares outstanding and is earning about a dollar a share. At 25 times earnings the stock makes sense because the company may be on the threshold of a great upheaval. Perkin-Elmer, Electronic Corp. of America, and Baird-Atomics also have stakes in the field, but I do not consider them appropriate vehicles at this time.

Another attractive specific technology is magnetics. There have been several exciting breakthroughs in the technology which have given this field a dynamic future. New types of ceramic magnets that are a magnitude stronger than conventional metal magnets, will create a revolution in the design of electric motors, and, possibly, automobile power accessories. Ferrite magnetic cores and magnetic drums are the heart of data processing memory systems. The most interesting and strongest company in the field, which also happens to be an investment-grade issue in my opinion, is Indiana General, which is slated to go on the Big Board soon.

In applied science there are 3 gems, 3 beautiful companies that stand by themselves. They are so great, so strong technically, that they virtually are the entire industry within themselves. There is

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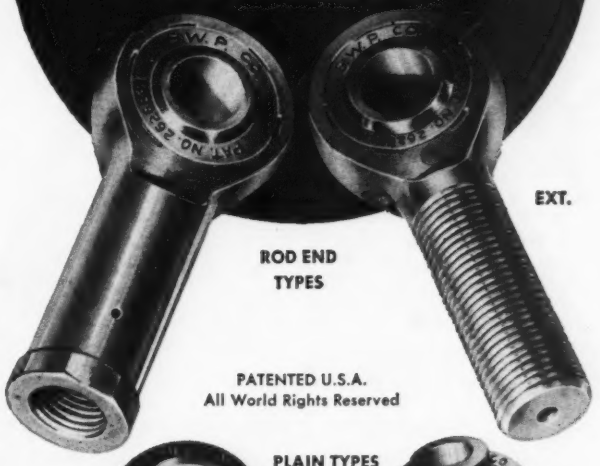

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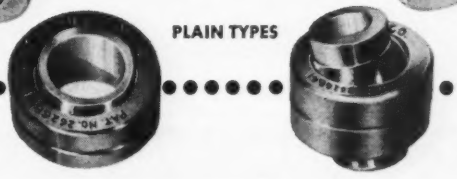

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nobody within sight of them. They are: Ampex in the field of magnetic recording, GE notwithstanding; High Voltage Engineering in the field of synthetic radiation and ion propulsion (the space craft of the future may be propelled by atomic particles generated from synthetic radiation generators); and Electronic Associates in the field of general-purpose analog computers.

There are a few small specialties which must be treated carefully. They are not suitable for average accounts, but they are extremely interesting because their small size makes them potentially explosive should they encounter even moderate success.

They are: Hermes Electronics, selling around 10. Included in this company's extraordinary technical staff are 3 Nobel prize winners who, related to the price, can be bought for $3.33 apiece! For those who like low-priced speculations, this stock has real validity.

C.G.S. Laboratories is a very small company. While its backlog is low, it has a strong technical group and some interesting proprietary products. Three hundred thousand shares, selling for $10, means only a $3-million equity base. There are the ingredients of a brilliant speculation.

I would also like to mention, as being very interesting, Electro Instruments, Milgo Electronics, and British Industries.

There probably are a number of other specific attractive technologies that deserve a place in this new approach, but there is the problem of space limitation. However, I do want to mention 2 areas that have been omitted deliberately: The first is molecular electronics or "minitronics," which has attracted the fancy of the market. Under this concept, an entire electronic circuit can be compressed into the space of a miniature device that now performs only one function. I think this development is overrated because it probably will be uneconomic for many years and, in the meantime, will find application only in such places as satellites where space and weight are compelling considerations. However, this whole subject is academic for the investor who has a position in solid-state physics because semiconductor companies are spearheading developments in this new field.

Another specific technology that does not appear relatively interesting is nuclear energy. The huge capital resources required in this business permit only the industrial giants to participate in the field, so the investor finds himself bumping up against the law of growth which says that big things do not display exponential growth. Radiation measurement and control instrumentation in nuclear applications is an extremely competitive field and a superbly managed, highly successful company like Nuclear of Chicago is the exception rather than the rule.

Over-the-counter list to be issued

Carl M. Loeb, Rhoades & Co. recently issued a list of over-the-counter securities which, in the electronics group, included Dictaphone Corp., Hewlett Packard, International Rectifier, Philips' Lamp, Polarad Electronics, Sprague Elec., FXR, Itek and Thomas & Betts. There will be paragraphs on each of these companies. You will notice these has been some overlapping with my remarks.

Let us now go somewhat outside of the portfolio that arises from my approach. After all, we are dealing with human beings and they are not going to buy this new approach overnight. If they do partially, do not let them buy one stock. Say: "I want you to buy a package." These are specialized companies. There is always risk in a specialized company, but you mitigate the risk by investing in several basic technologies or several specialized companies.

The standard conservative issues that we like are RCA, Sprague Electric and Electronic Associates. There are also the other acceptable blue chips: Litton Industries, Texas Instruments and Ampex. I may mention the same stock in different lists, but I am sure I don't have to explain that.

I consider particularly interesting a semi-investment issue Philco Corp. I believe that Philco this year could earn $1 per share from its solid-state physics business alone, which would by itself justify the present price of the stock. You get everything else

for nothing. That is the concept here. I don't know what everything else is worth; I don't know the value of the white goods business and the defense business and the computer business. But I do know that in 1959 Philco generated about $1.60 per share out of those businesses and I do know that management has been greatly improved. Philco strikes me as a good, standard speculation.

Closed-circuit television for industry, military installations and schools, and subscription television via cable, are two impending new markets of great promise. Maximum exposure is best achieved through Jerrold Electronics which, despite its $10-million size, is the strongest factor in the sophisticated business of distributing TV and FM signals over complicated coaxial networks. Here, again, we find one of the few really valid low-priced issues. The shares, around 8, earn about 35c on a fully converted basis and have a cash flow approaching 70c per share.

There is an interesting little specialty which I mention with some reluctance because there are only 88,000 shares in floating supply out of a total capitalization of 425,000 shares. Therefore, it must be treated judiciously. I don't know whether this has long-term validity because we have not checked it out. But we will. The company is Howard Sams. It's a publishing company, but it specializes in the publishing of technical material for the electronics industry. Its growth record is excellent and the concept of its business is intriguing. It may be a way of buying the electronics industry for 12 to 15 times current earnings. This fits into the concept of a Grolier Society and Crowell-Collier. While we have not yet checked it out, I did want to give you some insight into what we are thinking about.

If you were to ask me to select 4 great speculations with moderate risk but really extraordinary long-term appreciation potential, I would choose Polaroid, Farrington, Fairchild Camera and Itek. A package of low-priced attractive speculations would be Hermes Electronics, FXR, Jerrold Electronics, CGS Laboratories, Barnes Engineering and General Transistor.

It is obvious that the defense program is an important prop behind many of the stocks I have mentioned. You all have your own opinions about where the defense program is going. If you recall, when Khrushchev visited America the electronics group broke sharply. When other people in the Street said "sell out your defense stocks," we sent a wire to all our correspondents saying that they are going to come back. That's just what happened. I believe that the defense program will continue a long time. I believe that if it changes it will shift into the more sophisticated areas of new technology, the ones that I mentioned. I believe that if we do have an agreement with the Soviet Union, there will be a tremendous market for the control equipment necessary to police the peace. I also believe that if there is a real rapproachment on the military front with Russia, there will be a tremendous economic and technical competition with the Soviet Union, and that competition again will be in the laboratory and will be in these areas of advanced science.

Research and development depends upon money. It has been estimated that research and development expenditures have increased tenfold over the last 15 years and currently are about $10 billion annually, of which only 5% represents pure research. This great increase explains the exploding importance of applied science and the acceleration of new discovery in our time. However, we must be aware that in the scientific competition with Russia one dollar of research in our country is considerably less than the equivalent dollar spent by the Russians. In any specific technology in our country there are many companies that compete with each other, that keep secrets from each other and, therefore, that duplicate, several times over, research programs leading to new or improved products. On the other hand, the highly centralized research and development in the Soviet Union avoids duplication. Therefore Russia probably realizes much more from fewer research dollars than we do. This is one of the key reasons that our own R & D programs have been so inadequate, and it is also the powerful argument for ever increasing expenditures that will find their way into the basic technologies. This is the fertile ground in which well-planted dollars should grow vigorously.

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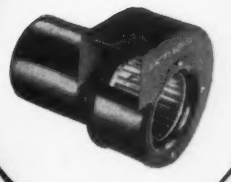

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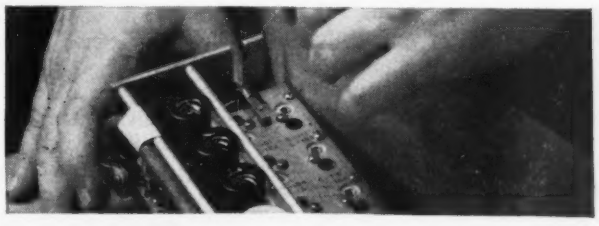

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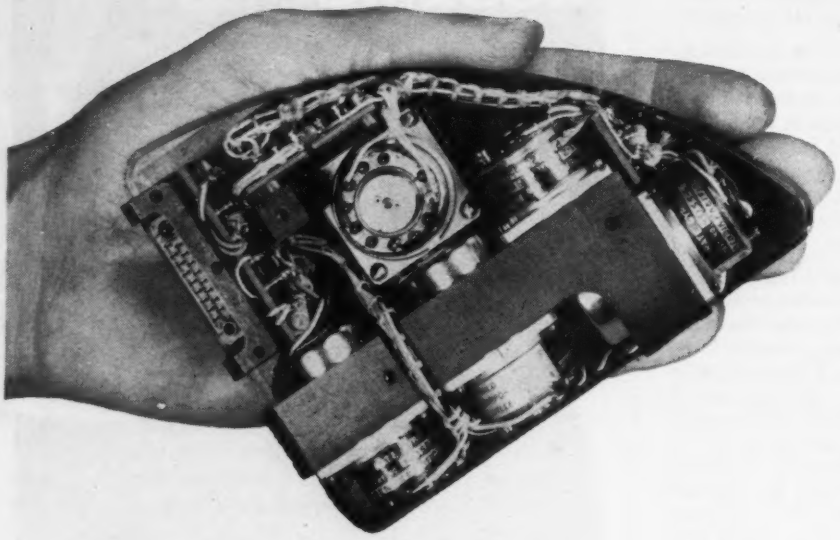


Fig. 1 Small enough to fit into the palm of the hand, wedge-shaped, subminiature gyro-accelerometer package supplies stable reference data to the autopilot in rocket-powered, pulse-guided Mark 46 torpedo. New design occupies half as much space as previous conventional designs.

GYRO-ACCELEROMETER PACKAGE

Self-Test Design Increases Reliability

Missile component and subsystem designers are paying greater attention to the design of equipment that can be tested for conformance to specs after they have been mounted in a missile. Obviously, total failure of a component affects the performance of a missile; but even minor or partial component failure causes deviations that make a mission useless in terms of accuracy.

Fairchild Controls Corporation of Hicksville, Long Island, has come up with a sub-miniature gyro accelerometer package that has incorporated the above design philosophy. The modular package consists of three sub-miniature RG-101 floated rate gyros (see ELECTROMECHANICAL DESIGN, Feb. 1959, pgs 8-10 for design details) and two sub-miniature TA-400 floated pendulous linear accelerometers. Each of the three gyros is oriented in one of three mutually perpendicular axes: roll, pitch and yaw; the accelerometers are sensitive to motions along the roll and pitch axes.

Myron Levitt, Manager of Fairchild's Gyro Department, pointed out that rate gyros were previously difficult to check out after mounting in a missile, since no angular rates existed before firing. "This meant," said Mr. Levitt, "that physical motion had to be imparted somehow to the missile while it was in its launching mounts. For smaller missiles, this was relatively easy to accomplish. Larger missiles and aircraft were not so easily moved. One solution to the problem utilized on a supersonic bomber was to have a technician jump up and down on one of the wings. In a very large missile the same results were accomplished by having a man hit the gyro mounting bulkheads with his hand. Obviously, these methods do not lend themselves to automatic countdowns."

Fairchild's sub-miniature rate gyros and accelerometers have self-test capabilities designed into the units. Appropriate design of the inductive pickoffs in these units makes possible a remote check of the gyros and accelerometers for important characteristics. Freedom of movement of the gimbal over its entire range of travel from limit stop to limit stop in most designs, allows friction or threshold level, sensitivity (funcioning of the torsion bar) and even damping ratio to be checked.

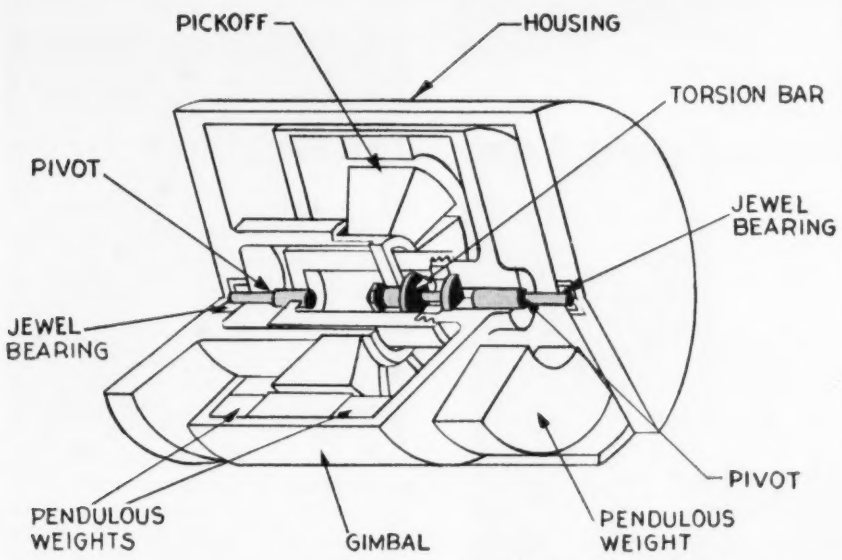
DESIGN DETAILS

In the gyro units the gimbal is supported by a pivot and jewel bearing at both ends, thus relieving the in-line torsion bar of supporting the gimbal under any conditions. A spider network suspends the torsion bar end of the gimbal. "With this design it's possible for very low range gyros (5 degrees per second) to withstand shock to 150 G's and higher," Mr. Levitt explained. In fact, he pointed out, the only limit to the amount of lateral G which the gyro can withstand is the pivot jewel design and the gimbal and motor mountings. The apparent rate due to lateral acceleration is also reduced greatly to only the amount due to the clearance between the pivot and jewel bearing in the pickoff end of the gyro. This clearance can be kept to only a few ten-millionths of an inch. The double pivot design makes the partially floated sub-miniature rate gyro performance approach that of a fully floated gyro.

"The pendulous accelerometer illustrated," said Mr. Levitt, "came about as a direct outgrowth of the sub-miniature rate gyro design. The accelerometer measures linear accelerations by means of a spring restrained unbalanced mass utilizing, again, two pivots to support the unbalanced gimbal and a torsion bar as the spring. The microsyn type inductive pickoff provides a voltage whose amplitude and phase are proportional to the relative position of the gimbal with respect to the housing. Fluid in the unit between the gimbal and the housing functions in the same manner as in the gyro. High performance capabilities under extreme environmental conditions, even for ¼ G maximum acceleration units, are possible."

In the self test feature for the gyro and accelerometer units, the pick-off is used to torque and to read out the gimbal position simultaneously. The pickoff can be used to torque the accelerometer for reliability or trouble shooting purposes in system testing. The pickoff is wired with additional taps so that a d-c or a-c excitation (filterable from the pickoff excitation) can be superimposed on a primary winding. This design will torque the pickoff and pendulum in either direction from null and generate an output signal in the winding indicating proper operation.

Since it is necessary to know whether or not the gyro motor is turning, and



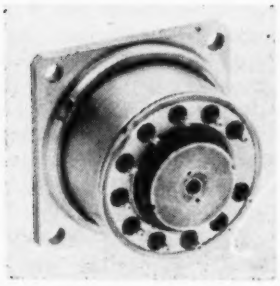


Fig. 2 Pendulous accelerometer measures linear accelerations by means of a restrained unbalanced mass. Two pivots and jewels support the unbalanced gimbal; the torsion bar functions as the spring. Microsyn type of inductive pickoff provides a voltage whose amplitude and phase are proportional to the relative position of the gimbal with respect to the housing. Size: 15/16 inches in diameter by approximately ⅝ inch long, The small angle through which the gimbal moves holds cross talk to a minimum.

if so at what speed, designers used a synchronous hysteresis motor to drive the gyro rotor. A pickoff coil wound around the outside diameter of the gyro housing picks up two different signals. "One signal," explained Mr. Levitt, "is due to the rotating magnetic field set up in the stator and its frequency is determined by the number of poles in the stator and by the line frequency. The other signal is due to the magnetic poles formed in the hysteresis ring and its frequency is a function of the wheel speed. When this second signal reaches the same frequency as the theoretical synchronous rotation, the rotor is locked in. A notch filter, designed for the proper rotational speed, effectively eliminates unwanted signals. However, for a two pole, 400 cps motor, at synchronous speed, the frequency of the rotating magnetic field and that of the mechanical rotation are the same, making it extremely difficult to tell when the rotor locks in.

"In this case a notch filter set at 350 cps gives an indication that the rotor has gone through that speed on its way to synchronism." Mr. Levitt pointed out that this design is not an infallible means of indicating synchronous rotation, since it is still possible for the rotor not to reach 400 rps after passing through 350 rps. However, knowing the run-up characteristics of the motor, it is extremely unlikely that it will not lock-in if the rotor does reach 350 rps. In addition, failure to achieve synchronous speed means only a lowered gyro sensitivity or a lower gain in the system—a much less serious failure than no rotation at all.

OTHER APPROACHES

Mr. Levitt pointed out that other means of measuring the rotor speed are possible such as use of light reflected from the rotor to a photo cell. However, in most instances other methods entail more complication. Another method is to pick up mechanical vibration of the gimbal by means of the pickoff.

Mechanical vibration results from the fact that the gyro rotor cannot be perfectly balanced and that the very small residual unbalance causes a vibration whose frequency is directly proportional to the rotor speed. Because the pickoff is sensitive to lateral as well as rotary motion, it will generate an output as a result of this vibration. A disadvantage of this method is that normally the signal is quite small.

Fairchild Control engineers feel that their gyro-accelerometer package has advanced the state of the art and that this technique for "self-testing" will insure greater reliability for present and future missile designs.

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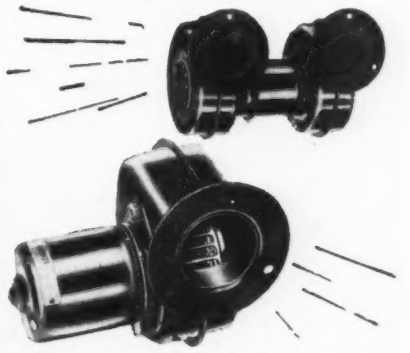

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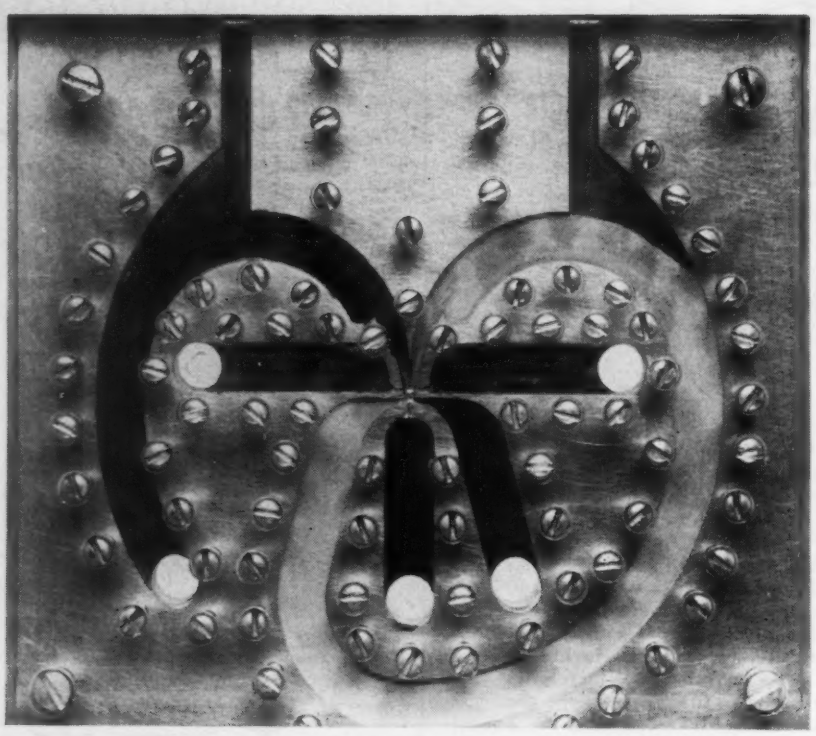

Fig. 1 Fluid system unit designed to operate flip-flop as used in a digital computer or digital control system.

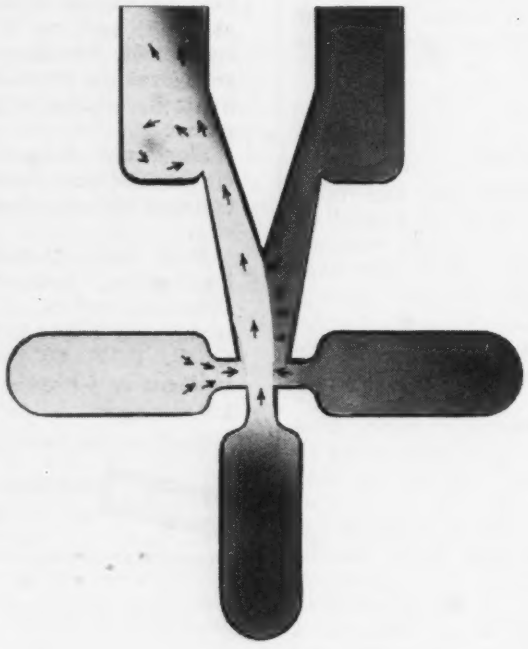

Fig. 2 Diagram of a control element in which low pressure between side wall and the power stream is used to help deflect the power stream. This phenomenon permits use of very low control pressures.

PURE FLUID AMPLIFICATION

Pneumatic Devices and Systems with No Moving Parts

Consisting, simply of a block of metal or heavy plastic material in which passageways have been made, a new family of control devices using gas or liquids as the working medium can perform the same functions as complex electronic circuits in a computer or control device. Civilian scientists at the Army's Diamond Ordnance Fuze Laboratories have successfully developed units that can perform amplification, feedback, digital and analog computation, normal mathematical functions and memory.

The basic building block of the fluid-actuated systems is the amplifying element, called a *pure fluid amplifier*, just as the vacuum tube and transistor constitute the basic building blocks of electronic systems. The function of the amplifier is to direct a low power stream of fluid against the side of a high power stream. The low power stream, called the *control stream*, is used to displace or redirect the *power stream*, in other words, the control stream tells the power stream where to deliver its energy.

This amplification by stream interaction can be described by the following example: Suppose a system is devised in which billiard balls are shot at high speed across a table and through an opening where they do some useful work. Now if a slow speed billiard ball were directed from the side against each of the high speed balls, they could be deflected, causing them to pass through a different opening and do their work somewhere else. This control of a high energy stream with a lower energy stream, whether it be billiard balls, liquid or gas, *is* amplifications.

Figure 1 shows a flip-flop suitable for use in a digital computer or digital control system. Feedback paths from the output apertures to two additional control nozzles (feedback nozzles) have been added, so as to "lock" the power stream in one path or the other. The unit can be changed from one of its two states to the other by introducing a small flow of fluid into one of the regular control nozzles.

Figure 2 is a diagram of a control element in which pressure in the region betwen the side wall and the power stream is used to help deflect the power stream. Use of a larger area in deflecting the power stream makes such

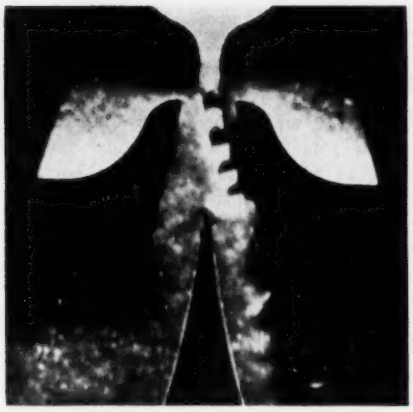

Fig. 3 Schlieren photo showing the actual flow of air through a pneumatic flip-flop which has a feedback action within the expansion chamber. The power stream is shown "locked" to the left wall.

a unit sensitive to very low control pressures.

Figure 3 is a Schlieren photograph showing the flow of air through a pneumatic flip-flop which has a feedback action within the stream interaction chamber. The power stream is shown "locked" to the left wall by a low pressure region which the power stream itself regenerates. It will stay locked to this side as long as fluid for the power stream is supplied, or until it is directed to the other side by the control stream. This principle of locking to a side wall makes possible a memory unit so "stubborn" that the power stream will stay locked in the path toward which it was last directed by the control stream, even though the flow out the aperture on that side may be completely blocked.

Major advantages of these fluid-actuated systems without moving parts are their simplicity and ruggedness which make them extremely reliable.

The capability of a pure fluid amplifier for high temperature operation undoubtedly goes far beyond that of any other known amplifying action, since the operation depends only upon the shape of a solid and the flow properties of a fluid. A properly designed unit could operate at white heat if a refractory material is used for the body, and a stable, non-corrosive gas is used as the fluid.

An important limitation of fluid-actuated systems is speed. They will never compete with electronic systems for the very high speed applications, but are much faster than fluid systems with moving parts, and their speed is entirely adequate for many applications, both military and industrial. Speed of response is adequate for signals in the audio frequency band.

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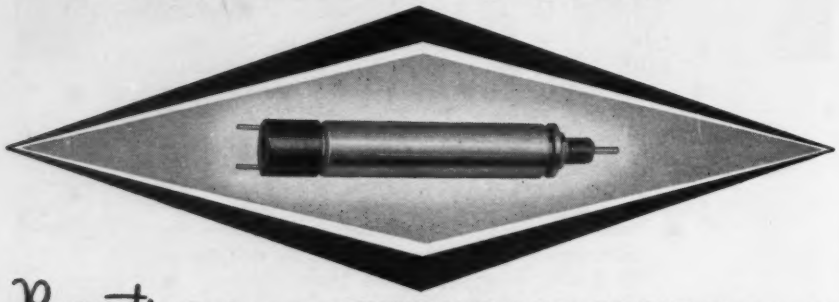

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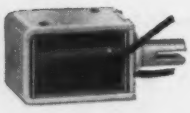

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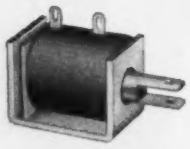

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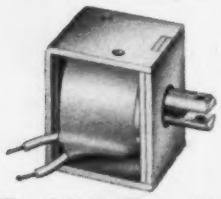

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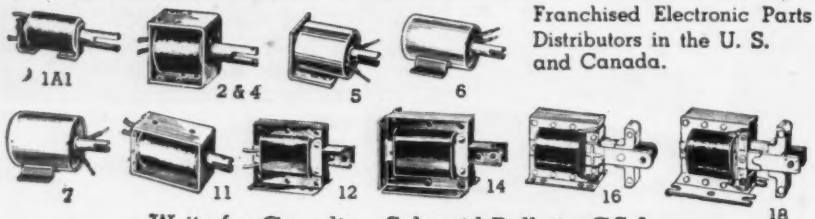

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A two-axis flight simulation table enables "flight testing" of complete missile or air-space craft stabilization and control systems on the ground. The table is also used for angularly displacing gyros and accelerometers, in pitch and roll, either statically or dynamically and as an oscillating table to determine the threshold characteristics of high performance gyros and accelerometers. Features of the table include extended angular travel over prior models, ability to handle a 25-pound load, natural frequency of each axis in excess of 15 cycles/sec, adjustable damping, and threshold of each axis less than .005 degrees. The table will follow signals from an analog computer, a low frequency function generator, a tape recorder, or a digital-to-analog converter. Micro Gee Prod., Culver City, Calif.

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Atmospheric-Particle Monitor

New atmospheric-particle counting instrument presents, on a strip-chart recorder, a permanent record of aerosols present in an overall range from 0.3 microns to any desired upper limit. This record is differentiated into 15 sub-ranges and recorded in sequence at intervals which can be predetermined in length. Stability problems are eliminated by the fact that the unit is continuously self-calibrated. Included in the instrument is an alarm system which can be set for a remote indication of particle concentrations in any of the monitored sub-ranges exceeding a predetermined maximum. Counting rate is 1000 particles per minute with a 1 per cent coincidence loss at the standard flow rate of 100 cc per minute. Operation is from a 115 v, 60 cps supply with a current of 3 amp. Royco Instruments, Inc., Mountain View, Cal.

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Microwave Ferrites

Ferrites designed for the microwave device engineer are illustrated in a new fourteen-page brochure. The brochure presents application information and describes a new line of low-loss ferrite materials with applications in the S, C, X, K_u, and K-band regions for isolators, rotators, phase shifters, switches and circulators. Solid State Research, Inc., Glendale, Calif.

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Small Tape Recorder

Claimed to be the world's smallest, an airborne tape recorder can be held in the palm of the hand and weighs only 24 ounces. It has been tested under actual operating conditions for vibration of 15 times gravity (without shock mounting (5 to 2000 cps) and impact of 2,000g (X, Y and Z planes). Other specifications include: size, 3⅜" diameter by 2½" long; tape speeds, 0.25, 0.5, 1.0, 1.875, 3.75, 7.5, 15 inches per second; tape widths, ⅛ inch and 1 inch; wow and flutter (under static conditions), less than 1 percent; power requirements, 24 volts d.c. Environmental features: acceleration, 200g; temperature, 50 to 200 degrees F.; relative humidity, 0 to 100 percent. Leach Corp., Compton, Calif.

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Automated Crystal Growing

A new semiautomatic crystal growing furnace with triple the production capacity of conventional furnaces is automated to reduce operational man hour requirements by 75 per cent. One technician, formerly required to tend a furnace at all times during the crystal growing cycle, can operate four of the new furnaces simultaneously. A control console virtually eliminates human error in crystal growing by complete and automatic programming of each production process. New method heats and melts larger masses of silicon with less power. Each operating cycle, including pre-gas, melt-down, pulling and drawing the ingot, is "push button" controlled. Also automated is the speed of the seed rotation, withdrawal time of the ingot and the cooling rate of the molten silicon. Temperature is controlled by a radiamatic pyrometer which uses a sapphire rod to transmit infrared radiation from the crucible to a thermopile or radiation-to-voltage transducer. This translates temperatures of 250 to 1,700 degrees C. to voltage outputs of from zero to 100 microvolts. A recording potentiometer produces a constant plot of temperature versus time. Hoffman Electronics Corp., L.A., Calif.

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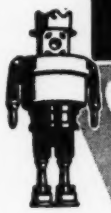
"Sel-Rex Gold Plate eliminated galling, increased resistance to wear of our connectors."



Cinch ELECTRONIC COMPONENTS

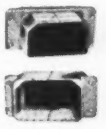
THE PROPOSITION: Research proved that some of the metallurgical properties of Gold would improve performance and reliability of new Cinch Connectors.

THE PROBLEM: Ordinary Gold plate's softness makes it susceptible to galling. And, because it is so soft and relatively porous, it wears readily exposing vital contact points to abrasive damage, corrosion — early failure.

THE SOLUTION: After extensive investigation, Cinch installed Sel-Rex Bright Gold because this patented formulation produces electroplate which is:
1) . . . twice as hard (115 Vickers, as compared to 65) and has demonstrated 40% greater resistance to wear and abrasion.
2) . . . far more dense — accelerated corrosion tests prove Sel-Rex Bright Gold plate gives many times more protection with a fraction of the Gold.
3) . . . mirror-bright in any thickness, directly from the bath—no scratch brushing or burnishing. Eliminating such costly postplating operations makes net costs lower too.

Exclusive Sel-Rex Plating Processes retain the desirable properties of the precious metals—eliminate the problems.

15 contact plug and socket D subminiature series.



23 contact plug and socket DPX series.

Sel-Rex SEL-REX CORPORATION
NUTLEY 10, NEW JERSEY
Exclusive Precious Metal Electroplating Processes

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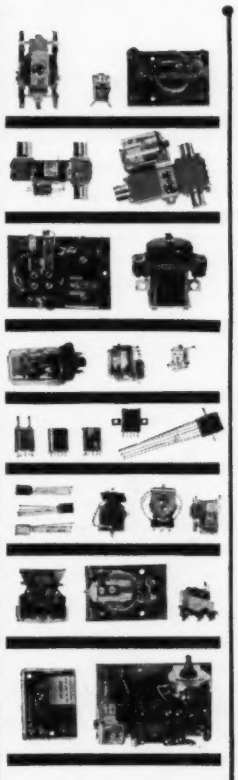
ELGIN ELGIN ELGIN ELGIN ELGIN ELGIN ELGIN ELGIN ELGIN

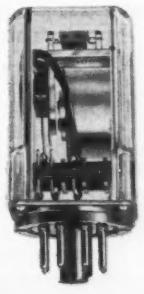


OFF THE SHELF

300 DISTRIBUTORS STOCK ADVANCE RELAYS

ELGIN ADVANCE RELAYS

FOR EXAMPLE:
A COMPLETE LINE OF GENERAL PURPOSE (GH) RELAYS ARE AVAILABLE FROM STOCK



These new Advance GH midget relays are engineered for high efficiency and low cost. A tremendous variety of applications permits countless uses. The small size of these midgets allows their installation in equipment where space is a problem. GH relays are available in three open Series—GHA (5 ampere rating), GHB (10 ampere rating), GHS (5 ampere plate circuit type). Also in three dustite plastic enclosure Series—GHP (5 ampere rating), GHH (10 ampere rating), GHE (5 ampere plate circuit type). Enclosures are supplied with 8-pin octal for 1C and 2C, 11-pin for 3C.

FOR GH SERIES DATA USE NUMBER BELOW

ELGIN ADVANCE RELAYS ELGIN-ADVANCE RELAYS ELGIN NATIONAL WATCH CO.
2435 N. NAOMI ST. / BURBANK / CALIFORNIA

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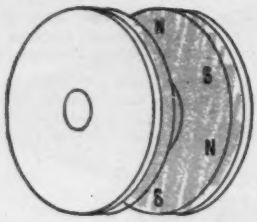
Indiana Permanent Magnets Can Simplify Drive Coupling

Permanent magnet drives often are the simplest answer in transmitting motion without mechanical connection.



Typical synchronous drive using Indox ceramic magnets

Magnetic Drive Types

Synchronous Drives. Both the driver and the driven member operate at the same speed. If slip occurs, the follower will slow and stop. Since displacement between magnets is required for torque, "hunting" may occur.

Hysteresis Drives are similar in operation to synchronous drives except that the driver magnet magnetizes the follower, creating a torque coupling that is synchronous up to the maximum torque capability. If this limit is exceeded and slip occurs, approximately the same torque will be produced regardless of the rate of slip. To produce a given torque, the hysteresis drive must be larger than a synchronous drive. "Hunting" may also occur. An *eddy current drive* may produce more torque for a given magnet weight.

Eddy Current Drives are non-synchronous and produce no torque unless some slip occurs. The greater the load, the greater the slip. If the load on the follower is reduced, it will pick up speed until slip is just sufficient for the load torque. Eddy current drives do not "hunt."

TYPICAL APPLICATIONS

Synchronous drives are used extensively in pumps, where one magnet is driven by a motor and another magnet follows with the impeller inside a sealed unit.

Hysteresis drives are used for yarn and wire tension devices to maintain uniform torque regardless of speed.

A typical application for an eddy current drive is in a take-up reel, where the torque is proportional to slip.

FREE DESIGN HELP

The Indiana Steel Products Company design engineers are ready to help with practical magnetic drive design recommendations, based on 50 years of experience with permanent magnet materials. Write today for this free service. Address Dept. V-6.

INDIANA STEEL PRODUCTS

Division of Indiana General Corporation

VALPARAISO, INDIANA

INDIANA PERMANENT MAGNETS

World's largest manufacturer of permanent magnets.

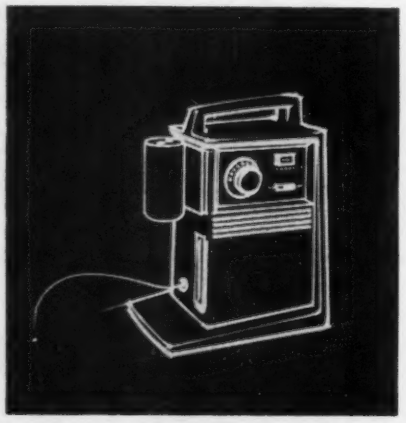
CIRCLE NO. 66 ON INQUIRY CARD

INDUSTRIAL PRODUCT STYLING

Industrial design improves product appearance, but, just as important it eases manufacturing problems and reduces production costs.

Materials and manufacturing processes characteristic of industrial design are gaining recognition by manufacturers of non-consumer products. Metals Controls Division of Texas Instruments, Inc., Attleboro, Mass., realizing that the engineering skill and precision going into the design and manufacture of its non-consumer products was not being reflected in the appearance of the finished units, engaged Paul Wrablica Associates, New York City industrial designers to add a quality look to its products.

Redesign of a thermostat test unit resulting from this collaboration illustrates the contribution industrial design can make in easing manufacturing problems and reducing costs, as well as in styling. The test unit is a portable device used in various manufacturing facilities and in field checks to determine the correct range of temperature control in appliances.



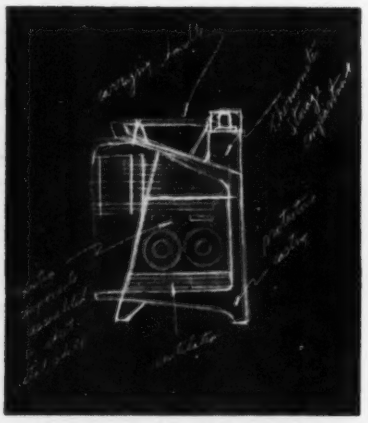


Fig. 1 Preliminary Phase. It was determined that unit should be in its own carrying case, with built in compartment for storage of the glass thermometer. Existing components were retained, but repositioned. The Variac control knob was moved to the side, which allows greater access, readability and minimizes the danger of its touching cylinder which contains the heating element.

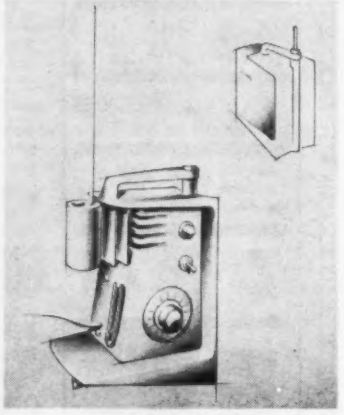


Fig. 2 Rendering indicates stainless steel finish. All wire leads are routed through one side of the unit, improving the assembly procedure as well as appearance.

Fig. 3 The finished product: A well designed instrument manufactured at an estimated 30% savings.

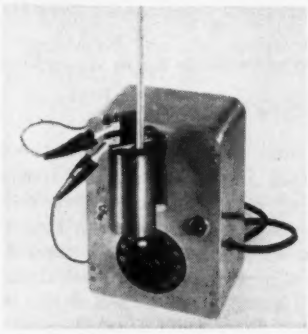


Fig. 4 Original version of the portable Tube-Type Thermostat tester.

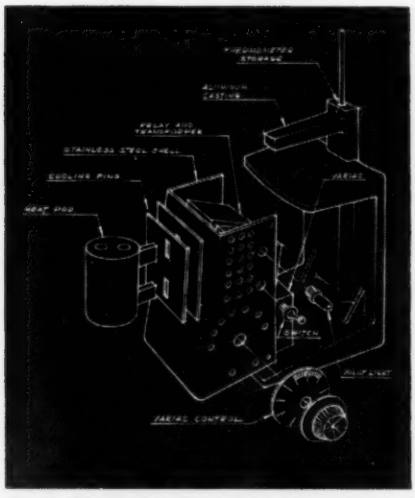


Fig. 5 Exploded View Drawing. Subassembly of all compartments in stainless steel wrap around for easy assembly and access. Stainless steel part with standard punch die ventilation perforations, is made from flat stock and formed on a brake, thus eliminating the cost of a die (estimated at $3,000) and reducing material cost. Compactness and distribution of internal components are planned for ease of assembly and repair. The sand casting is designed for simple reproduction in limited quantities. The handle, an integral part of the assembly, provides protective storage for the accessory thermometer in the upright column; the curved surface under the handle grip provides compact over-all height without sacrificing area for the hand; and the shape affords "built in" quality control by minimizing rejects due to possible sags in the casting.

Less than .005" Runout on a 24" Shaft...

Holtzer-Cabot Solves Fractional H.P. Motor Problems

Holding runout tolerances on a motor shaft extending 24" beyond the motor frame poses a difficult design problem. To reduce runout, many manufacturers have resorted to complicated and expensive outboard bearings and shaft supports. To avoid this problem, one such company* came to Holtzer-Cabot, which in cooperation with the company's engineers, developed a motor with a special extended end cap and a heavier shaft. The result: less than .005 runout at one inch from the end of the 24" shaft.

Write for Information! Holtzer-Cabot specializes in the design and manufacture of fractional horsepower motors for all types of applications. For complete details on Holtzer-Cabot motors for specific applications, and a copy of "Key Factors in Selecting AC Motors for Instrument Service" write direct or use Readers Service Card.

**Name on request*

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MOTOR DIVISION

National Pneumatic Co., Inc., Boston 19, Mass.

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Midposition Force (lb.)	2.5	5.0	8.0	13.0
Hysteresis (%)	2	2	2	2
Resonant Frequency (CPS)	940	790	580	400
Max. Power Req'd (Watts)	1.6	2.65	3.1	5.2
Weight (oz.)	2.8	5.8	9.0	19.5

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MATERIALS

NEW THERMOPLASTIC MATERIAL

High Physical Stability For Component Design

The Mobay Chemical Co., Pittsburgh, Pa. announces that results of experimental applications for a polycarbonate resin, called "Merlon", indicate that it will meet functional and processing requirements now beyond the limits of many of the present plastics. Among the most significant properties of the polycarbonate plastic are exceptionally high impact reistance, excellent dimensional stability, and greater resistance to heat, moisture and weather than most of the available thermoplastics. Unlike many other plastics, it will not splinter when struck by a sharp object such as a bullet.

The electrical and mechanical properties of the molded plastic remain stable between a low temperature point of —400°F and a heat distortion point of 280-290°F. In processing, the Merlon resin can be heated to 425-610°F without decomposing chemically. Because of its self-extinguishing characteristics, the plastic is expected to be used in many applications where fire is a hazard.

The material can be processed by any of the conventional thermoplastic methods. No plasticizers are required in the polycarbonate resin, a factor that eliminates many problems encountered with thermoplastics containing plasticizers. Polycarbonate parts can be machined, sawed, stamped, solvent-bonded, and heat welded or heat sealed. The resin can be made into shapes, rods, tubes, sheet, and film. Because of its combined high strength and ease of fabrication, the material is being evaluated as a replacement for laminated plastic.

Among the applications in which the plastic has demonstrated excellent functional characteristics during experimental phases are: insulators and insulating board and mountings; cable wrapping; capacitors; distributor caps; meter cases; telephone sets; computer components; bushings; hose nozzles and couplings; connectors, electric coil forms and stator slot liners.

Write No. 174 in Box on Inquiry Card

Sponge Rubber

In addition to providing resistance to fuels and lubricants at extreme high temperatures a fluorosilicone sponge rubber compound possesses immunity to aging, ozone and weather hardening; excellent dielectric properties and good compression set resistance. It is highly suitable for soft gasketing, vibration dampening, fairing strips, pads, cushions and other applications. Connecticut Hard Rubber Co., New Haven, Conn.

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Moisture Barrier Seal

The need for an absorption type seal that can breathe with the thermocycling of ceramic insulated elements is met with a moisture barrier seal called AerOseal. It operated continuously in the temperature range of —400 degrees F to 1000 degrees F and withstands a thermal shock from 1000 degrees F to —300 degrees F in two seconds. If the maximum temperature is exceeded, AerOseal will lose its moisture resistance quality but will not carbonize or have a deleterious effect on the insulation resistance of the material on which it is used. AerOseal is an inorganic sealant suitable for nuclear applications. Aero Research Instrument Co., Inc., Chicago, Ill.

Write No. 504 in Box on Inquiry Card

Fiberglass Cloth

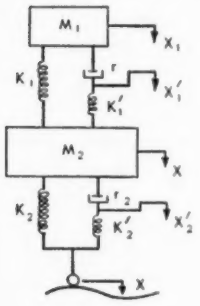
Designed essentially to replace varnish-impregnated cotton tapes, an impregnated woven fiberglass cloth is described by the Sun Chemical Corp., Nutley, N.J., as having high physical strength in relation to its weight, excellent dimensional stability, exceptional tensile strength, low elongation, good dielectric properties and high resistance to solvents and chemicals. The impregnated cloth, identified as Acto-Glas Mark II, is supplied in the partially cured stage, and when subjected to heat, pressure and time cycles, it becomes a fully cured homogenous material in the nature of a laminate. Applications include insulation of coils and armatures in rotating equipment and coils in power and distribution transformers. Physical stability permits its use as random tying tape during the making-up of transformer coils. The impregnated cloth can also serve in the banding of armatures and as a replacement for conventional steel banding on medium and large motors. Electrical coils can be taped with normal tensions being applied due to shrinking of the cloth during the curing operation giving a secure and snug fit. Sun Chemical Corp., Nutley, N.J.

Write No. 505 in Box on Inquiry Card

DOUBLE MASS — SPRING SYSTEMS

There are many instances in which it is desirable to reduce transmissibility (the ratio of the transmitted force to the impressed force) to values lower than that obtainable in a single mass-spring damped system. Curves have been developed for the single mass-spring system, and are available in most standard texts on mechanical vibrations, but little has been published on multiple-spring systems. Here's a recently developed series of transmissibility curves for a double mass-spring system for use in the design of high-speed track carriages.

In this particular instance, one mass, (M_2), represented the mass of the sprung carriage and the other mass, (M_1), represented the item undergoing test. The design objective was to design the doubly sprung system so that track imposed forces would be reduced to a minimum at the test item, i.e., maximum vibration isolation of the test package from vertical accelerations. These transmissibility curves have proven useful for several design applications, and could be used in a number of vibration absorption problems.



$$M_1\ddot{X}_1 = K_1(X_2 - X_1) + K'_1(X_2 - X'_1)$$

$$M_2\ddot{X}_2 = K_2(X - X_2) + K_1(X_1 - X_2) + K'_2(X - X'_2) + K'_1(X'_1 - X_2)$$

$$r_1(\dot{X}'_1 - \dot{X}_1) = K'_1(X_2 - X'_1)$$

$$r_2(\dot{X}'_2 - \dot{X}_2) = K'_2(X - X'_2)$$

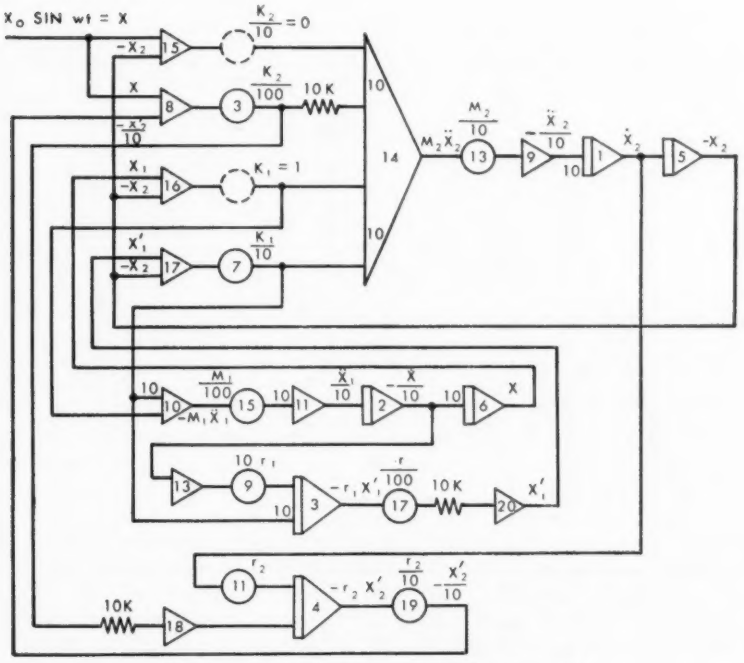


Fig. 1 Basic System and Analog Prepatch

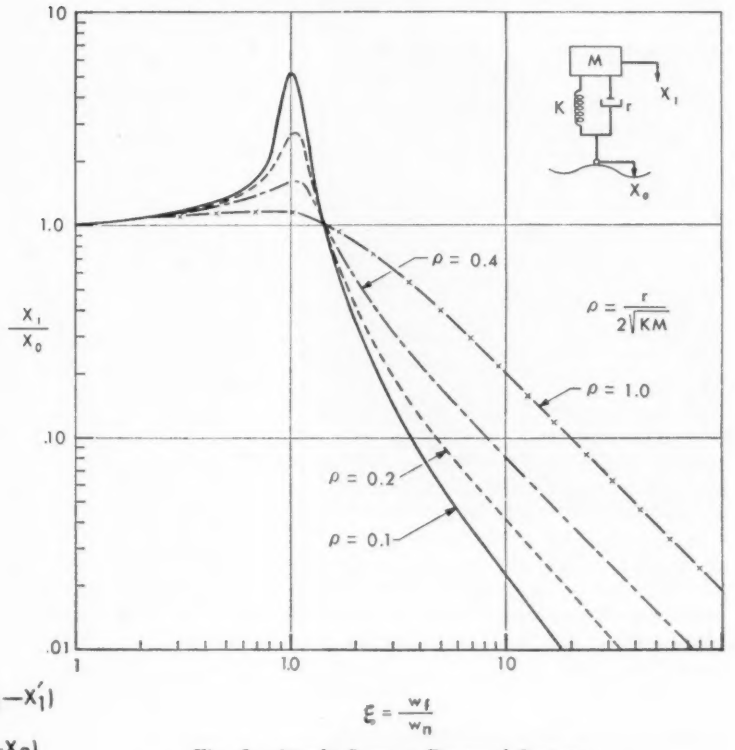


Fig. 2 Single Sprung Damped System

The equations of motion (Fig. 1) were solved on the Reeves Analog Computer which is ideally suited for these types of problems. Calculated values of each of the points on the series of curves would otherwise take considerable time. A pre-patch of the system is also shown on Fig. 1. The imposed forcing frequency is assumed to be harmonic and the springs linear.

For comparison to the double mass-sprung curves, a standard single mass transmissibility curve is shown in Fig. 2. Transmissibility is plotted vs. frequency ratio for varying amounts of the damping ratio.

Figures 3, 4, 5, and 6 are typical transmissibility curves for the double mass-sprung system. A family of curves result by varying the following dimensionless parameters:

$\mu = M_1/M_2$	Mass ratio
$\nu = W_1/W_2$	Frequency ratio
$\eta_{1,2} = K_{1,2}/K'_{1,2}$	Spring ratio
$\rho_{1,2} = r_{1,2}/2(K_{1,2}\,M_{1,2})^{1/2}$	Damping factors

In regard to the curves the follow-

ing should be noted:

• As a dashpot under initial shock will have little compliance, a second spring K′ connected in series to the dashpot has been introduced.

• Since we are primarily interested in the accelerations of the two masses, the ratio of $|X_1| / |X_0|$ and $|X_2| / |X_0|$ have been used rather than the ratio of displacements.

• Consider, for example, Fig. 3 for $\xi = 10$, $|X_1| / |X_0| = 1.5$ and since

$$|X_1|/|X_0| = \omega^2 |X_1| / |X_0|$$

then $|X_1|/|X_0| = 1.5/10_0 = 0.015$, the original displacement has been reduced by 98.5%. If we compare this with Fig. 2 with $\xi = 10$, then $|X_1|/|X_0| = 0.023$.

By reference to the curves, it can be seen that the larger reduction in transmissibility of the top mass results from a smaller mass ratio μ and smaller frequency ratio ν. Thus in Fig. 5 for $\xi = 10$, $|X_1|/|X_0| = 0.11$ and $|X_1|/|X_0| = 0.0011$, which reduces the original displacement by approximately 99.89%. However, since less energy is being absorbed by the top mass, the lower mass will have a higher acceleration than that shown on the curve previously

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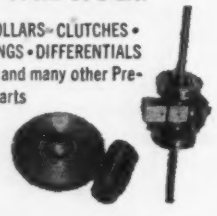

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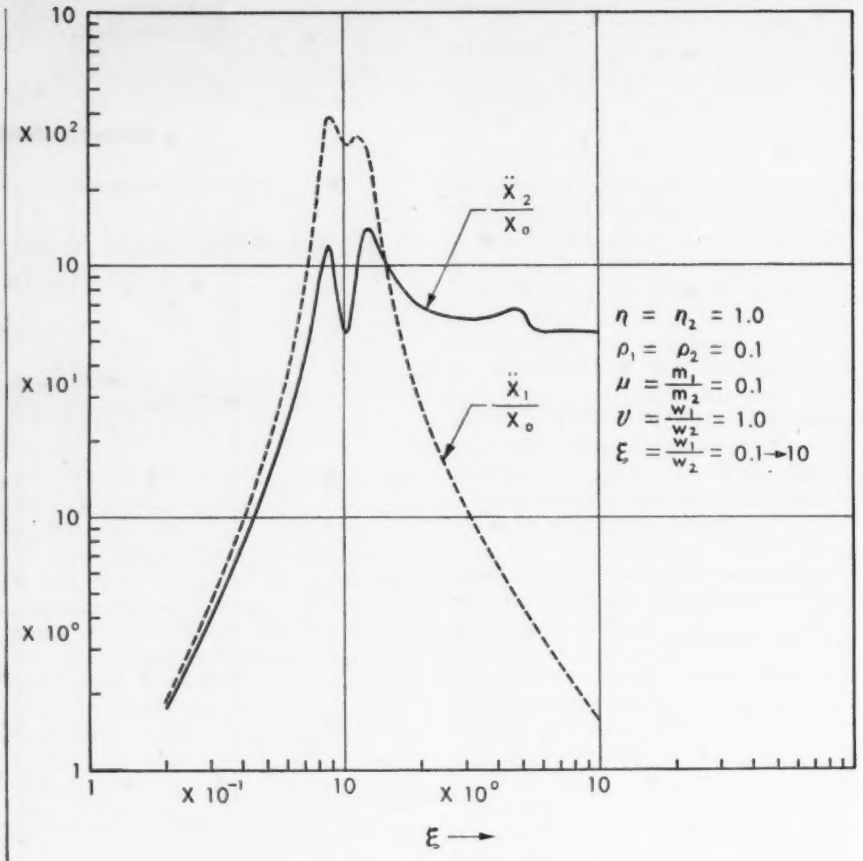


Fig. 3 Double Sprung System

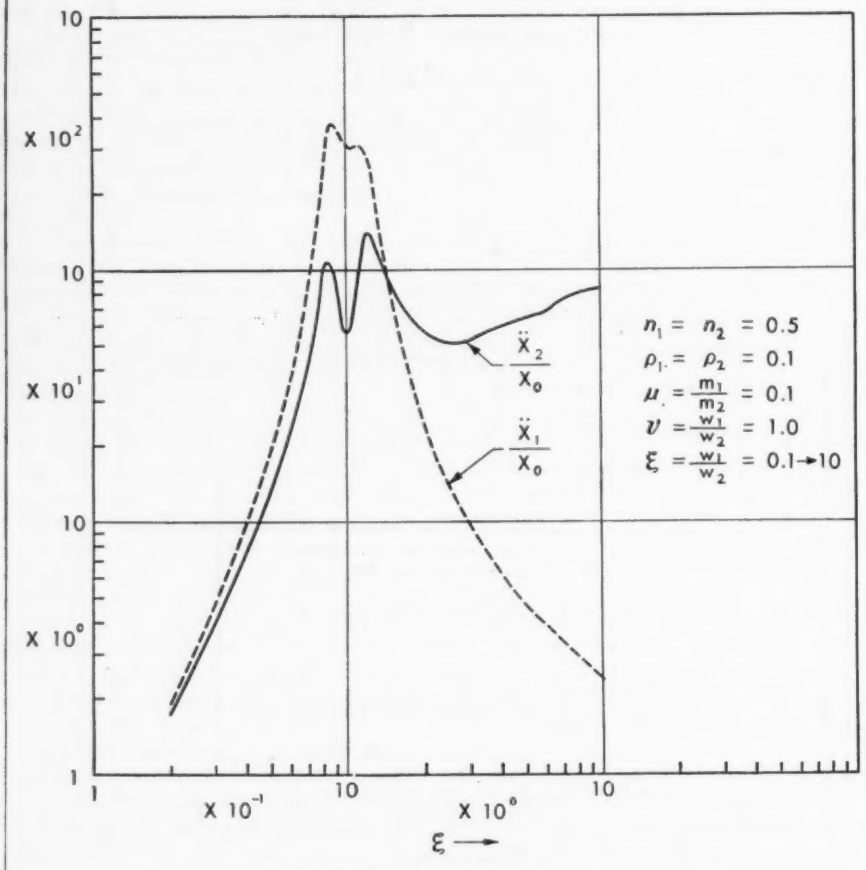
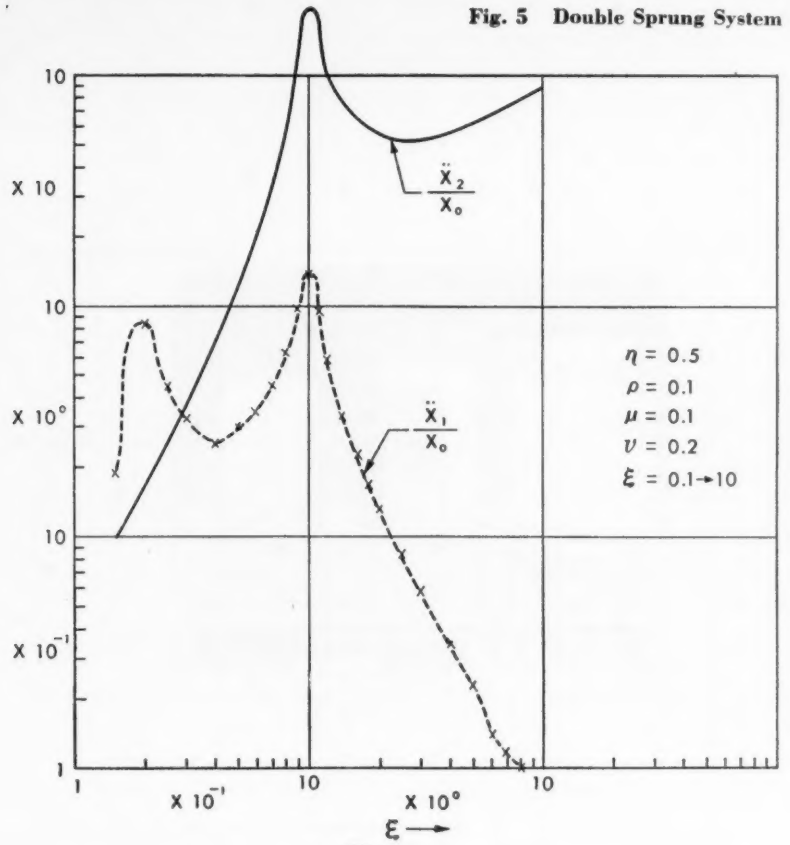


Fig. 4 Double Sprung System

Fig. 5 Double Sprung System



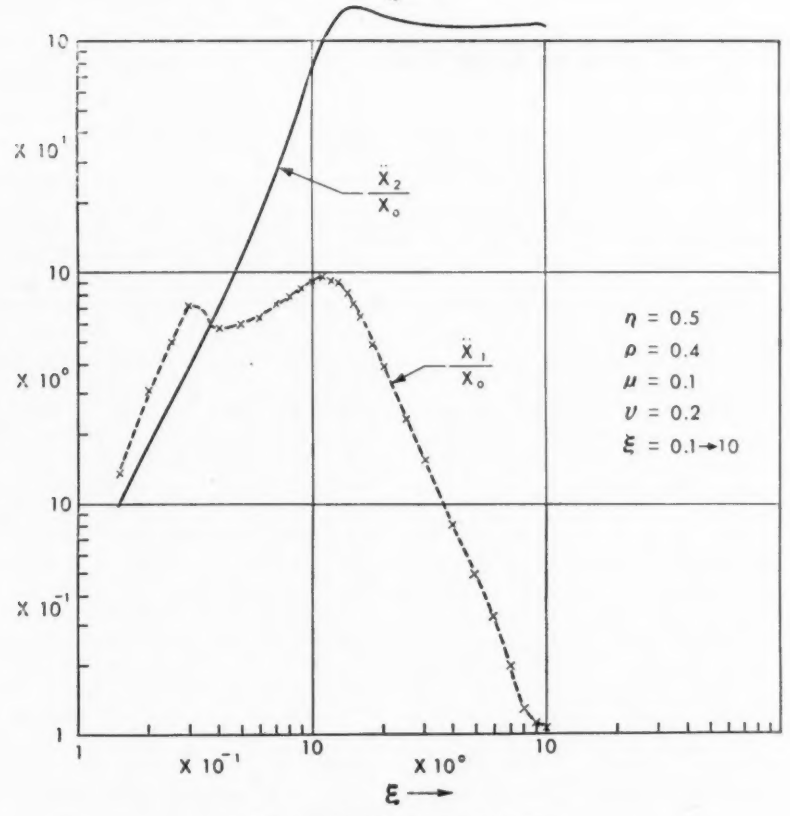
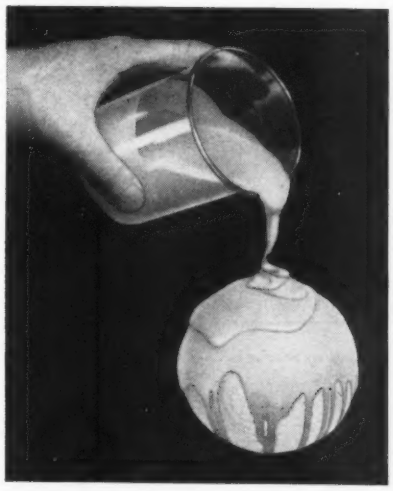


Fig. 6 Double Sprung System

analyzed. In all cases, however, there is considerable reduction in transmissibility to the top mass when compared to the lower mass.

These curves can be applied to the design of any system requiring great attenuation, and will be particularly useful where a large amount of vibration isolation is required. The curves also have general value in the study of multiple harmonic systems under steady state oscillations.

General Electric RTV*
LIQUID SILICONE RUBBER



Cures at room temperature, useful from −70°F to +600°F

General Electric's expanding family of RTV silicone rubber compounds all cure at room temperature. They contain no solvents; resist temperature extremes, moisture, ozone, weathering and aircraft fuels. Available in a wide range of viscosities from 120 poises (lower than any other silicone rubber compound) to 12,000 poises. Important application areas include:

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Aircraft manufacturers use RTV for pressure sealing of cabins and cockpits, fire walls, fuel tanks and hot air ducts. Protection for electronic packages is provided by caulking assemblies and sealing seams and lead holes with RTV.

ELECTRICAL INSULATION

Good electrical properties and outstanding heat resistance have led to RTV's use in coil impregnation and encapsulation of motors and transformers. Can be poured, sprayed, painted, or applied by dipping. Cure times can be varied from minutes to several days.

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Parts cast in flexible RTV molds reproduce with precision detail. Built-in parting agent assures easy release. RTV eliminates such common problems as excessive shrinkage and separate release agents.

*Room Temperature Vulcanizing

For more information and a free test sample, write (briefly describing your application) to General Electric Company, Silicone Products Department, Section 9, Waterford, N.Y.

GENERAL ELECTRIC

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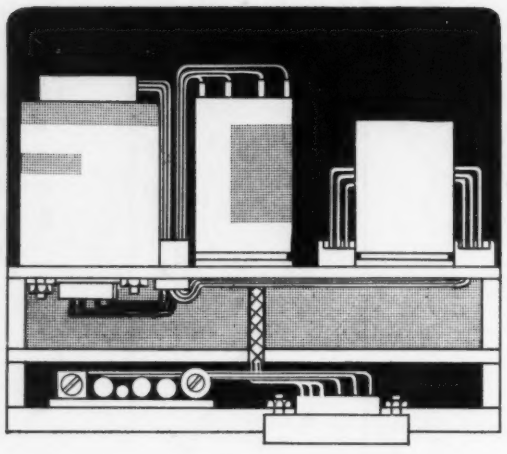
COMPONENTS 15 DIGEST



Miniature Servo Packages

The increasing complexity of modern instrumentation has resulted in the need for miniature standard packages which could be considered as components but which perform functions covered in the past by sub-systems. Thus it is now possible to purchase a whole servomechanism in a simple compact package to do a job that once required a specially designed arrangement of gears, amplifiers, rotating components and other hardware. This progress in standardization and packaging quite naturally follows the growth in system design techniques where relatively complex arrays of elements are described by a box with an associated transfer function. It is likely that as repetitive functions of even greater complexity are encountered, that these functions will be isolated and eventually more or less standardized and packaged.

It is to be expected that difficulty in standardization is in direct proportion to the number of variables in the function, which accounts for the fact that even in the relatively simple field of miniature instrument servomechanisms there is very little uniformity. When one remembers how long it has taken to fashion standards for relatively simple devices such as servomotors or potentiometers, this lack of uniformity in the field of servomechanisms is not surprising. Nevertheless, some common design approaches do exist, permitting a basis for ordering specialized servos which may be minor modifications of so-called manufacturer's standards.

This Components Digest 15 surveys the types of available standard packages, discussing the more popular features, and tells the project engineers how to go about ordering the best one for his particular application.

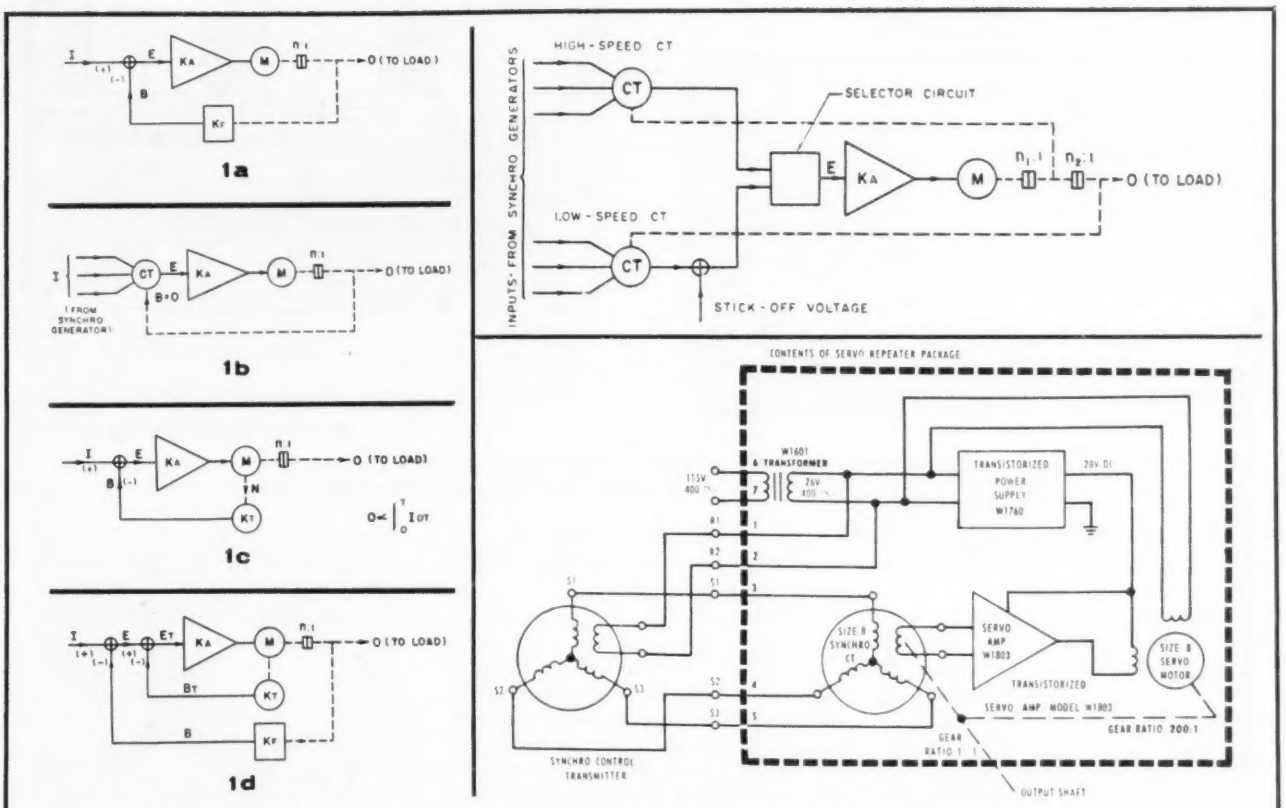
The ability to transform a relatively complex sub-system into a semi-standard compact package has resulted quite as much from miniaturization of components as from advanced system thinking. The problem of packaging the bulky, heavy components of the past into anything resembling a handy package would have been insurmountable. Today's servomechanisms incorporating synchros, amplifier, data elements, and gearing are hardly larger than was a simple synchro about 10 or 15 years ago. Probably the development of the transistor amplifier has contributed most toward this end. It may be that new efforts in molecular electronics will lead to a situation where the electronics are a relatively minor ingredient in terms of volume, and the big push will be to reduce rotating components down to size 5 and perhaps 3. There are still many problems in this area, which we will discuss.

BASIC COMPONENTS OF A SERVO PACKAGE

The systems man sees a servomechanism as a "black box" which generally has an electrical input, and either an electrical or mechanical output, or both. Fig. 1 shows schematically an assortment of special-purpose servomechanisms which might be required, and which the manufacturer of the servo package must consider prior to "standardizing". What he must do is to design a line of basic subassemblies which may be readily modified to suit the widest diversity of applications, and with an eye on competitive pricing, he must be sure that the "specials" are not too costly or bulky as a result of his standardization. In general, the greater the degree of standardization, the simpler and less expensive the prototype but the more complex and expensive the productions unit.

Generally speaking, all servos may be represented by the block diagram in Fig. 2, which shows the standard array of an actuator responding to the output signal of the error detector to drive the output shaft and its sensitive data element to correspondence with the input electrical signal. The load elements driven by the output shaft provide electrical signals for external use.

As a start in the miniaturization problem, consider a basic unit in terms



Figs. 1 (a) through 1 (e) show common configurations which frequently occur in miniature servomechanism packages.

Fig. 1 (f) Waldorf Instruments' package based upon the schematic of Fig. 1 (b). This servo-repeater is available in a 1 31/32″ dia. by 4″ long can.

of which other servomechanisms may be described with simple variations. Assume a conventional ac instrument servomechanism for remote positioning. Here a miniature 2-phase servomotor, available down to Size 5, provides the mechanical power. A miniature transistor amplifier energized from a 28 volt dc source provides the control field power. An ordinary summing network is fine as an error detecting circuit, providing a signal to the transistor amplifier when data element (output potentiometer) signal and input command signal do not agree. An output potentiometer, nonlinear if desired, is conveniently available ganged to the data element potentiometer.

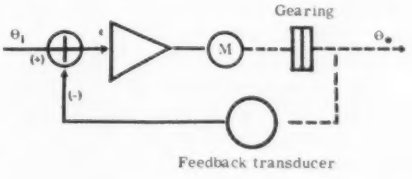
The basic ingredients of this package are a motor, servo-amplifier, ganged potentiometer gearing, a basic chassis or frame, plus an assortment of miscellaneous electrical and mechanical parts. Similar packages may substitute synchros as the data element, and provide additional components for driving as an external load. Often dial readouts are required for information purposes, and zeroing and checking for proper operation. The size of individual components may vary, the larger components being preferred where cost and/or accuracy take precedence over miniaturization.

The package problem becomes more difficult and pilot surfaces and precisely aligned mounting means are essential, when an output shaft is required to drive an external member, not part of the servomechanism. Where low speed, high torque loads are involved, the structure must be sufficiently rigid to withstand the reaction strains at the point of mounting.

COMMON VARIATIONS

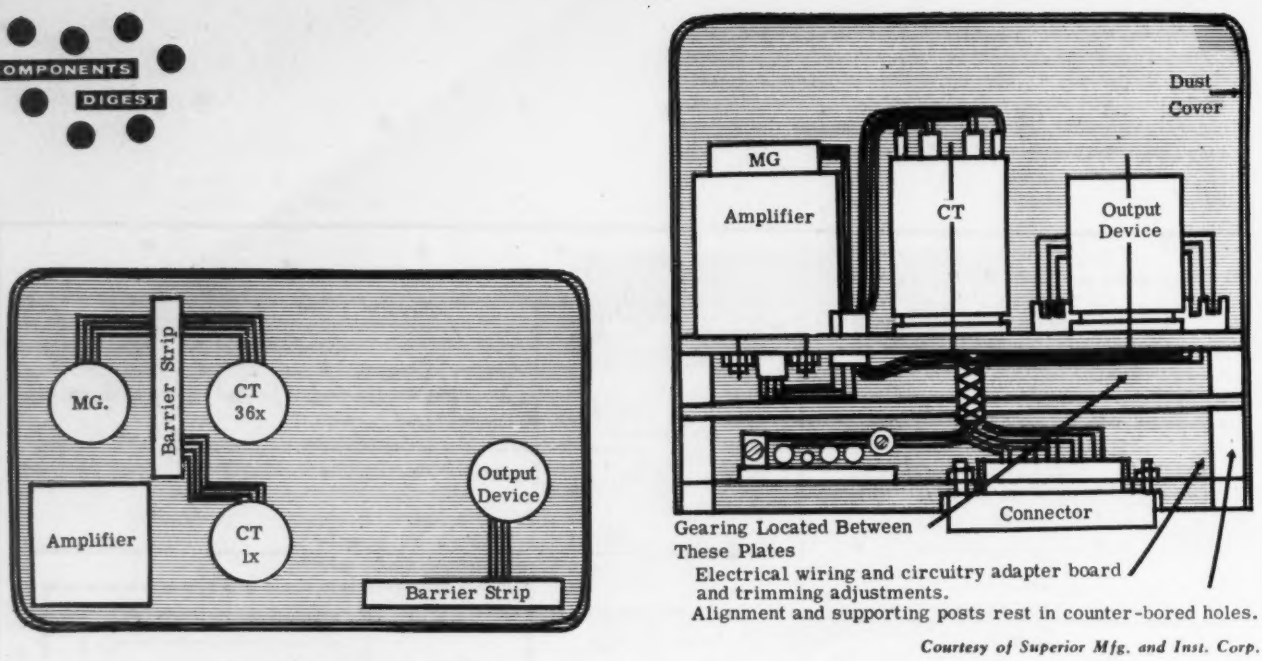
Try as he may to standardize, and economical as his standard packages may be, the servomechanism manufacturer will find that most of his customers want specials. Consider some of the more common variations.

- To simplify the damping problem a motor-tachometer is often specified where the tachometer provides a particularly convenient damping signal. Tachometer null voltage must be low in very high gain positioning servomechanisms.
- An external amplifier may be preferred, not incorporated within the servomechanism package. This may be done to save space in a critical area, or more likely so that the customer may use his own amplifier. This approach



θ_o may be used directly as a shaft output, or it may drive one or more electrical output elements.

Fig. 2 Servomechanism block diagram.



Courtesy of Superior Mfg. and Inst. Corp.

Fig. 3 Basic layout of a servomechanism package. The package is designed for flexibility, the nature of the output device depending upon the application.

complicates the cabling, and may lead to pick-up problems in the cable circuits.

• A two-speed synchro repeater system may be required, either with or without read-out dials. This type of system is preferred where highly accurate positioning of the output device is required. A typical output device would be an electrical resolver or a two-minute accuracy synchro. The precision of the gearing is the limiting factor in accuracy, and since gearing errors increase sharply with decreasing pitch-diameter, extreme miniaturization may not be feasible.

This problem of how far to go in standardizing is considered again later.

CONSTRUCTION FEATURES

Some degree of uniformity has been achieved in packaged servomechanisms in spite of the lack of standardization. Fig. 3 shows the most basic layout where gearing is mounted between a pair of parallel jig-bored plates on either or both of which are mounted the rotating components. The figure shows how alignment is maintained between the plates even though repeatedly assembled and disassembled. The rotating components generally have standard synchro-mount front ends for convenient coupling in properly sized and located holes on the jig-bored plates. The cleat mounting permits simple removal of the component, and makes it especially easy to zero or line up the system.

Depending upon the details of the application a variety of construction features may apply, adding to uniformity and ease of servicing of the product: see Table I.

ALTERNATIVE CONSTRUCTION

Difficulty in standardizing servo-packages has resulted in a variety of drastically differing package designs, each suitable in its own limited area. A common construction, available from many sources, is the in-line construction, illustrated in Fig. 4 This figure shows the package incorporating motor, gearhead, and precision potentiometer, a most versatile combination. Supplementary components often include a feed back tachometer, integral with the servomotor, perhaps other shaftmounted damping devices, friction-type slip clutches, and single-turn or multi-turn limit stops. The coupling between the motor-gear-head package and the potentiometer must be rugged enough to perform its function under application shock and vibration requirements without adding excessive length to an inherently overlong package, and with sufficient flexibility for easy zeroing of components.

As with all design packages, sacrifice of flexibility and departure from strictly standard major components results in greater compactness and frequently improved environmental characteristics. Often the shaft of the motor may be used as the potentiometer shaft, considerably shortening the package. A single housing extending from the motor gearhead to include the potentiometer can entirely eliminate the special coupling. This technique is often

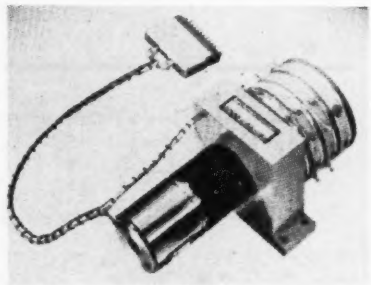


Fig. 4 Typical in-line type servo construction. This construction is advocated by a number of manufacturers who provide special hardware to simplify packaging.

applied to clutch shafts, and similar output members. Such devices simplify zeroing, and frequently allow ganging by the addition of separate adjustable potentiometer cups. Sometimes a shaft extension is available where further elements or an output dial must be driven.

Another in-line construction used frequently where no mechanical output is required is exemplified in the quadrature rejection unit of Fig. 5. This simple motor-gearhead-potentiometer employs viscous damping at the motor shaft for stabilization. Although the feedback potentiometer need not be highly linear, good resolution is essential. Miniature carbon film potentiometers have been very successful in applications of this type. Since there is no mechanical output required, all connections being electrical, it has been feasible to hermetically seal the assembly in a can with a connector provided for the electrical terminations.

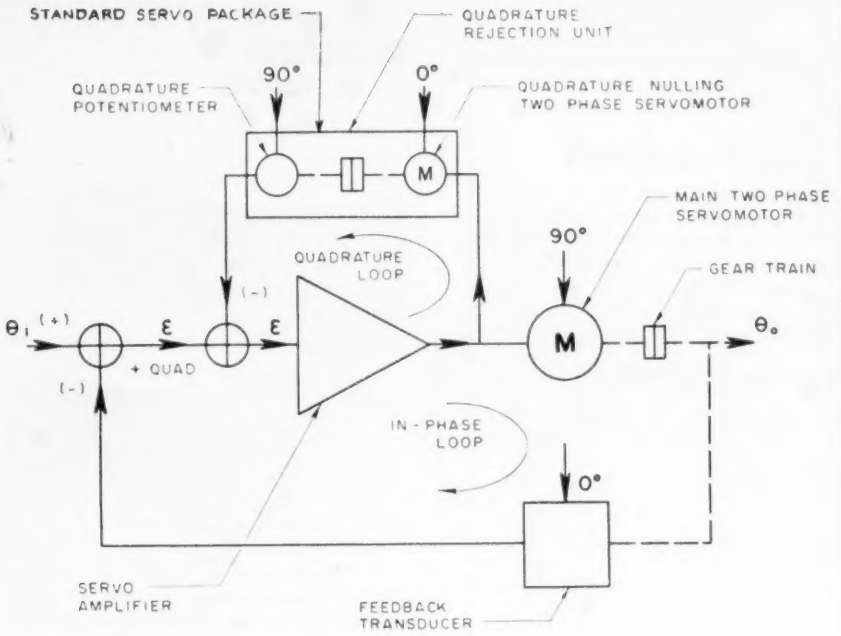


Fig. 5 Quadrature rejection by means of a motor-gearhead driving a high resolution quadrature excited potentiometer in the feedback loop. The standard servo package is available from a number of manufacturers.

Cans require no precision mounting, and are easily replaced for servicing.

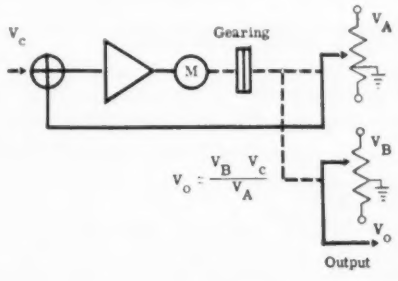
Fig. 6 shows almost the same assembly used for function generation, or voltage multiplication. Accurate and versatile multipliers are feasible in this configuration. Choppers, either mechanical or solid-state, permit multiplication of ac and dc voltages.

In general, the in-line construction offers advantages of simplicity and directness with a minimum of packaging difficulty and special tooling. The primary disadvantage is its length. The unit is generally the longest unit of a group, making subsystem packaging more difficult. If it is end mounted the long cantilever arm presents difficult shock and vibration problems. Heat dissipation may become difficult due to the relatively great distance from the source (the motor windings) to the sink (the mounting surface). With stainless steel housings, heat flow by conduction is poor, the temperature rise being perhaps double that with an aluminum housing. However, the stainless steel housing may be necessary for strength requirements. The heat conduction problem is very important at high altitudes where very little heat is lost by convection.

Table II lists some of the more common in-line servomechanism packages.

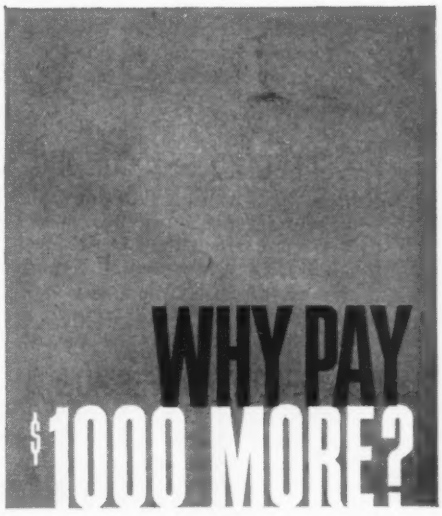
INDICATOR TYPE DEVICES

Indicators and read-out devices are specialized but highly important types of servomechanism packages. They are primarily remote indicating systems designed in a round case with the smallest possible components. Torques are low, the principal loads being bearing and gear friction. Output dials and pointers may contribute appreciable inertia. Because of the relatively slow rate of change of physical variables indicated on the meter faces, substantial gear reductions occur, with a consequent reduction in load reflection back to the motor. Construction details may be especially complex because of the required compact packaging. Fig. 7 shows typical servo indicator packages driving two different types of read out devices.



Courtesy Waldorf-Inst.

Fig. 6 "Standard" servomechanism for multiplication and division of electrical signals and function generation. The mechanical elements comprise a gearhead motor coupled to a ganged potentiometer.



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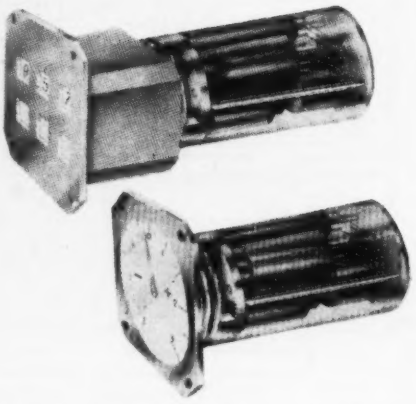


Fig. 7 Indicator-type servo packages showing indicator and dial type readout.

TABLE I

Typical design features of basic package servomechanism

The servomechanism package is built around a set of rectangular paralled plates which provide the mounting surfaces for locating electromechanical components, gearing, mechanical hardware, and electronics. The design requirements are based upon the following principles.

1. All rotating components easily replaceable using only simple tools. Gears on shaft must not exceed component diameters.
2. Zeroing and aligning require no major disassembly, merely loosening and retightening of readily accessible clamps.
3. Cabling incorporates the following features:
   (a) All harness connections to terminal boards and caps so that lead-type rotating components may be removed without opening the harness.
   (b) Cabling neatly run from the separate plates with adequate slack so that individual plates may be separated without disconnecting.
   (c) All disassembly performed without aid of soldering iron.
4. All trimming and calibration elements mounted on a separate easily removable board.
5. Square posts permitting mounting of separate cover plates as a partial seal around the gear box.
6. Mounting of output device not incorporated on basic plates. Easily added when output device is suitably identified. For convenience the plates may be a bit longer than anticipated and cut to length as required.
7. Wider plate separation is possible if more room is needed for special electronic or electromechanical components.
8. If output dial readings are required, the output connector may be located (with sufficient cable slack) somewhere in the cover. The adapter board can be omitted, and the electronic components mounted on separate plates.

MINIATURE COMPONENTS—SERVOMOTORS

The art of miniaturizing servomechanism packages is limited primarily by availability of miniature components. It is appropriate therefore to review the state of the art in miniature servomechanism components.

The most popular of the Bureau of Ordinance standard servomotors is still the size 11, followed by the size 15. This popularity is primarily due to the fact that over the last ten years the price of these frame sizes has been reduced sharply, and they have established themselves as readily available, thoroughly proven components. Size 11 is preferred in newer instruments where its size advantage gives it an edge over the size 15. The sizes 15 and 18 servomotors are used where their extra shaft power is of importance.

Size 10's have in some instances supplanted the size 11's, but the slight size improvement over the size 11 has not given it a decided advantage. Among the size 10's are some models markedly reduced in length, but these suffer in torque per watt characteristics.

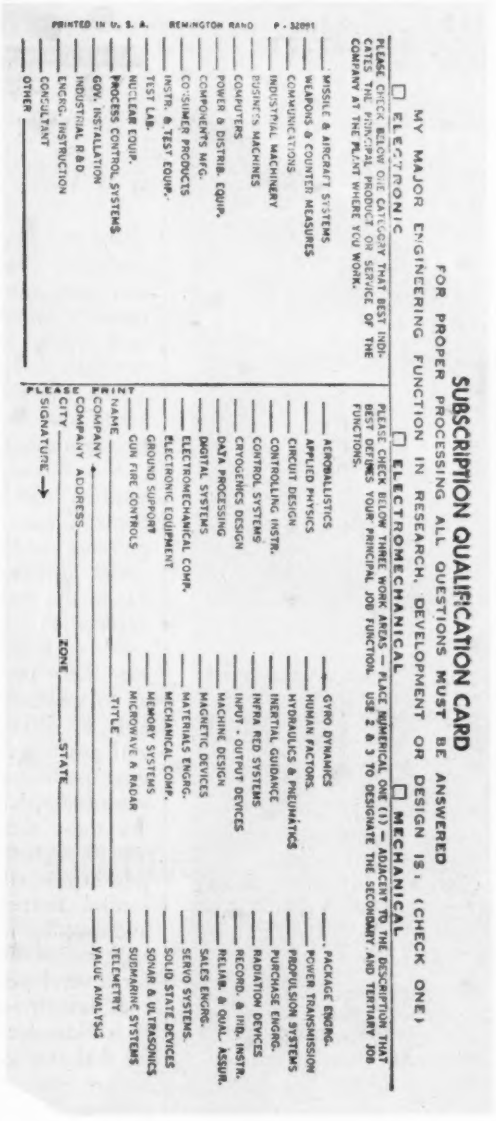
Probably the most popular motors in the near future will be the size 8's. They deliver from 1/3 to 1/2 the torque of the size 11's but this is usually sufficient to drive the light loads of instrument servomechanisms, Some manufacturers have designed the size 8 servomotor to pull the same stall power as the size 11 in an effort to achieve highest torques. This has led to excessive temperature rise, and failure in use. In general the size 8 specifications have been less conservative than those of the size 11. One very prominent instrument manufacturer (at least) has stated his intention of staying with

TABLE 2

Common In-Line Packages

1. Motor ± Gearhead
   (May include anti-backlash gears limit stops, etc.)
2. Motor ± Gearhead ± Slip Clutch
3. Motor ± Tachometer
   (Either for damping or integrating)
4. Motor ± Brake
5. Motor ± Viscous Damper
6. Motor ± Inertial Damper
7. Motor ± Gearhead ± Tachometer ± Brake
8. Motor ± Gearhead ± Damper ± Coupling ± Potentiometer
9. Motor ± Gearhead ± Clutch ± Potentiometer
10. Motor ± 2-speed gearhead

watch



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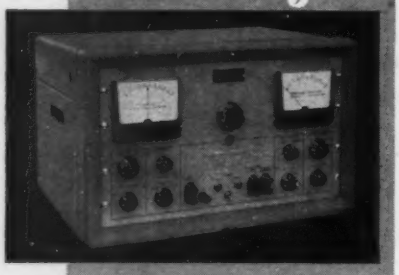

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size 11's, which have been thoroughly evaluated over the last several years, and postponing use of the size 8 in projects emphasizing reliability until a comparable record of performance is established. In spite of these considerations, the size 8 is here to stay and many models are available in production quantities.

Size 5 components today occupy the position held by size 8's two years ago. Some firms regard them as "toys", pointing out that torque values are very much lower than those of sizes 8 or 11, in the order of 0.1 oz-in. In many applications where useful shaft load reflected back to the motor is negligible, there may still be some question as to whether enough torque is available to drive the lubricated bearings and gearing at low temperature. Tight gear meshes and thrust loaded bearings accentuate this problem. Notwithstanding these difficulties, it is likely that size 5 motors will play an important role in miniature indicators and lightly loaded instruments, but performance and application problems as well as high prices may delay their acceptance for several years.

Although some size 3 motors (1/4 inch diameter) have appeared, it may be that this size is not practical. Since torque per watt falls sharply as diameter decreases below a certain level; the size 5 may represent the lower limit in the forseeable future.

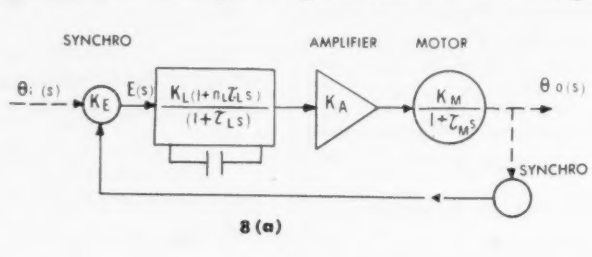
Part of the delay in popularizing any miniature motor frame is the requirement for a *complete line* of components to use with it. A motor that is much smaller than the other components in a servo packaging, offers little advantage in packaging. Designers are not apt to use a motor unless gearheads, and motor-tachometers are available in the same frame size.

SERVO-AMPLIFIERS

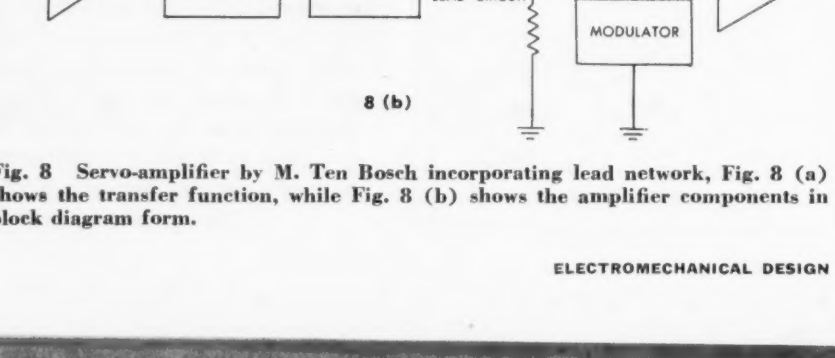
Probably the biggest size reductions have taken place in circuit electronics. Here, of course, advances in semi-conductor technology have provided the stimulus. Molecular engineering techniques show promise of reducing the low power circuit elements of a servo-amplifier to compact solid structures of extremely minute proportions. High efficiencies of these solid-state elements in comparison with vacuum tube equivalents means corresponding reductions in the sizes and capacities of power supplies.

Size reduction of power stages is limited by efficiency considerations. The amount of heat to be dissipated depends directly upon the load power requirements. Adequate heat conductions paths must be provided from transistor to exterior case. The frame size and mounting heat sink must be adequate to dissipate losses without excessive temperature rise of the transistor. Choice of inexpensive high efficiency germanium transistors, or costly silicon types depends upon the total temperature at critical transistor junctions.

It has become almost standard practice to avoid the use of an output transformer by substituting a push-pull connection of the motor windings. These windings may be so arranged on the motor that no net dc flows within the magnetic circuit of the motor. Push-pull motor control windings of 40 volt



8 (a)



8 (b)

Fig. 8 Servo-amplifier by M. Ten Bosch incorporating lead network, Fig. 8 (a) shows the transfer function, while Fig. 8 (b) shows the amplifier components in block diagram form.

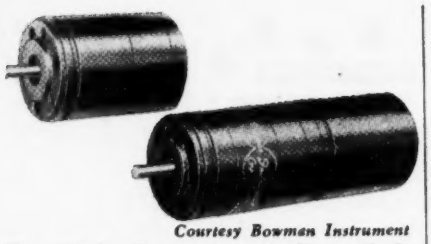


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Fig. 9(a) Internal stops limit shaft rotation. Slip clutch protects motor and gear head from damage.

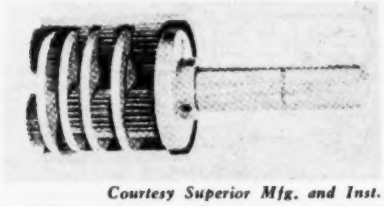

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Fig. 9(b) 21-gear planetary gearhead designed to adapt into housing connected to high speed ac or dc motor. Torque in excess of 50 oz.in. can be attained at 4000 to 1 reduction.

Fig. 9 Less common gearhead constructions.

TABLE 3

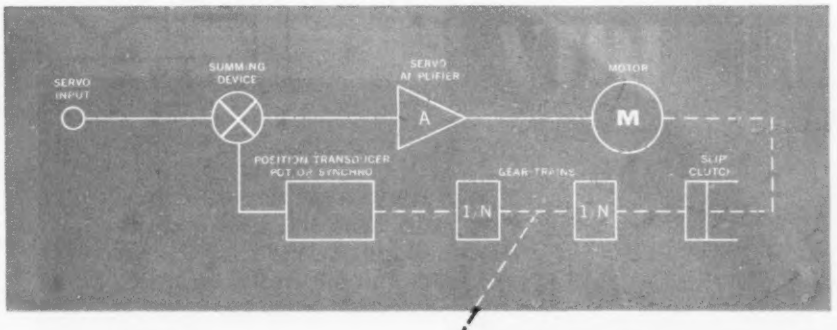
Typical Gearhead Variations

1. Two-speed gearheads, electrically controlled.
2. Gearheads adaptable to standard unmodified servomotors.
3. Gearheads with heavy hardened output stage for high torque loads.
4. Planetary gearing for large reductions and high shaft torques in a compact package.
5. Spring-loaded output gearing for low backlash.
6. Gearheads incorporating slip clutches, limit stops, etc.
7. Special gearheads for adapting to output clutch, potentiometer or similar device.
8. Gearhead which fits into extension of motor housing.
9. Ball bearing vs. sleeve bearing gearheads.

rating are commonly encountered for application in transistor circuitry. Probably the most difficult items to pin down in standard servo packages relate to dynamic performance. Much of this difficulty arises from the nonlinear character of electromechanical servomechanisms. Gear backlash and friction, because of their variable nature, contribute most to the uncertainty. For this reason it is important to allow substantial stability margins and to check the servomechanism over all operating extremes.

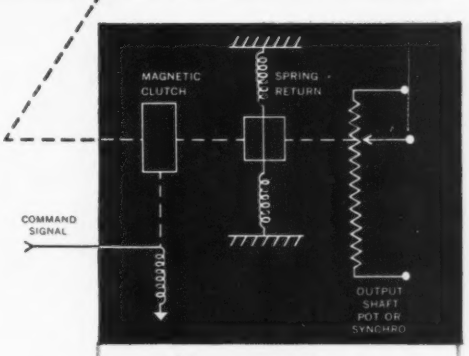
On new designs, where the stability problem is not clear cut, it is useful to set up a bread-board based upon stock parts now available from many suppliers. These stock parts have been improved in precision and miniaturization in recent years, and make it possible to go quickly to an easily adjustable bread-board whose performance closely approximates that of the final

PROBLEM: To provide an output Potentiometer-Transdu which can be readily engaged with a minimum angular error to a servomechanisms gear train when energized by an external command signal. The transducer must accurately return to a specified null position when the command signal is removed.



A SOLUTION:

Provide an electro-magnetic clutch, spring return mechanism and rotary potentiometer. Assemble these parts into the required package with the resultant difficulties brought about by the mounting and coupling problems with a consequent increase in cost.



THE OPTIMUM SOLUTION:

TIC *unitized package*

Technology Instrument Corporation's west coast engineering facilities developed and offer a unitized package consisting of an electro-magnetic clutch, spring return mechanism and rotary potentiometer as one compact assembly. The clutch will transmit high torque without slippage and has negligible angular engagement error. TIC's unique spring return mechanism will accurately return the output transducer to the desired null, yet requires low driving torque. TIC's unitized assembly replaces three (3) individual components with their inherent assembly difficulties.

GENERAL INFORMATION:

Shaft Position Transducers can be linear or nonlinear potentiometers, synchros, linear transformers or digitizers. Spring return mechanism can be supplied designed to return to any desired point. A built-in slip clutch can also be furnished if the input torque can exceed the rating of the clutch.

TIC UNITIZED PACKAGE HAS MANY APPLICATIONS, SUCH AS: Auto pilots, altitude controllers, machine controllers, measurement and control problems, speed control, process control of temperature and flow, differential measurement, expanded scale servos, or any other problem requiring an output, commencing at some specified servo position determined by an external command signal.

TECHNOLOGY INSTRUMENT CORPORATION

Subsidiaries: Technology Instrument Corp. of Calif. North Hollywood, Calif.
Acton Laboratories, Inc., Acton, Mass.
TIC of Arizona, Tucson, Ariz.
TIC of Illinois, Franklin Park, Ill.
Altomac Corp., Canton, Mass.

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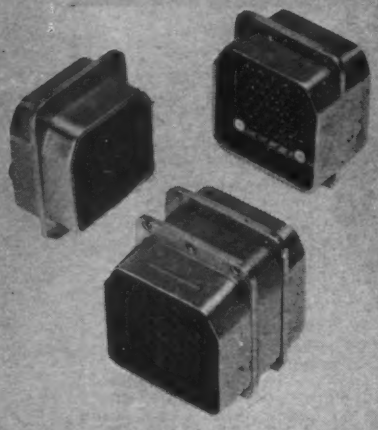
Acton, Massachusetts

CIRCLE NO. 77 ON INQUIRY CARD

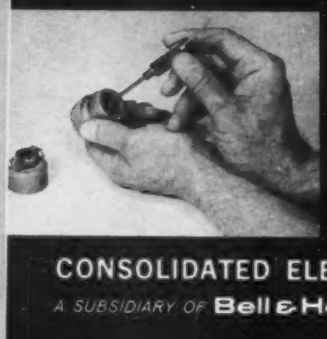
THIS IS YOUR FIRST LOOK AT CEC'S TWO NEWEST CONNECTORS

HIGH-ENVIRONMENT CIRCULAR TYPE designed to meet MIL-C-26500. This is CEC Series 600, 700, 800 for critical altitude, temperature, and reliability requirements of high-performance aircraft, missiles, and space vehicles. Resilient silicon-rubber seals provide liquid immersion resistant assembly. Available with 24, 31, and 55 removable, crimp-type contacts and choice of square flange or jam-nut receptacle mounting. Write for Bulletin CEC 4005-X2.



RACK AND PANEL RECTANGULAR TYPE with die-cast aluminum shell. CEC 500L Series with crimp-type contacts designed to meet MIL-C-26636. Available in 48- and 63-contact configurations with sizes 16 and 20 contacts. Two standard RG58/U coaxial contacts are included in the 48-contact connector. Insulator blocks of both new connectors are high-strength, glass-filled Diallyl Phthalate. Write for Bulletin CEC 4006-X2.

CEC also manufactures a full line of rectangular connectors (Series 500C) which feature snap-in, crimp-type contacts. This series is available in a wide variety of mounting configurations with 26 to 104 contacts. Write for Bulletin CEC 4004-X26.



A complete line of accessory tools for easy crimping, insertion, and removal of contacts is available.

Electro Mechanical Instrument Division CEC

CONSOLIDATED ELECTRODYNAMICS / pasadena, california

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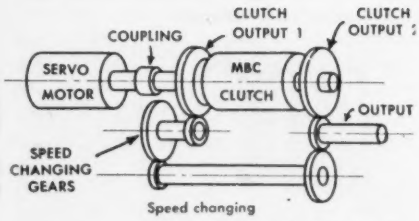
COMPONENTS DIGEST



Courtesy Autotronics, Inc.

Fig. 10 The clutch will couple its input drive shaft to either of the two output shafts, depending upon energization, to carry out the speed-changing function.

package. Here friction and backlash are readily varied to determine the sensitivity of the servomechanism to these parameters. Particular attention should also be given for the effects of resolution in a feedback potentiometer.

Tachometer feedback is the commonest method of instrument servomechanism stabilization. Damping built directly into the motor package is particularly helpful in improving stability in the presence of nonlinearity. Electrical networks have been used less frequently than they merit. They can certainly provide good, readily controlled stabilization. M. Ten Bosch now manufactures a compact servo-amplifier incorporating a lead network for closed-loop stabilization as well as a circuit designed to reject quadrature signals. This seems like another step toward combining functions for standardization of larger basic subsystems.

GEARHEADS

Gearheads have been developed hand-in-hand with miniature servomotors. An AGMA program to standardize miniature servomechanism gearheads is under way. Much more progress in this area is needed. Size 8 gearheads are currently available from a number of sources, and size 5's are usually available on special order. The reader is cautioned that special gearheads may be expensive, typically hundreds of dollars, with lead times ranging from six weeks on up.

A degree of confusion has arisen in the gearhead business since the fact that the gearhead often costs several times as much as the servomotor. Consequently, many motor manufacturers make their own gearheads, or

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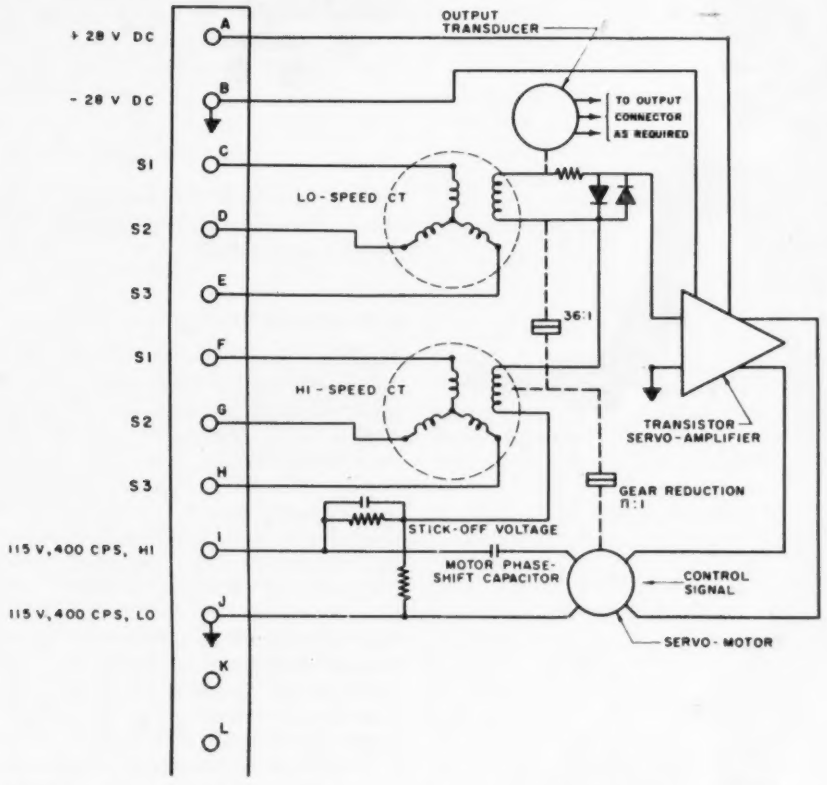

Fig. 11 Schematic diagram of two-speed repeater package by Superior Mfg. and Inst. Ordering information provides concise check list of points to consider.

have acquired gearhead manufacturing facilities. Some gearhead manufacturers on the other hand buy relatively standard servomotors and market the motor-geared combination themselves. Thus there are many varieties of gearheads available at substantially different prices. The cautious user will shop carefully and make no assumptions as to quality without a follow-up check. Fig. 9 illustrates some specialized gearhead types and Table III lists some of the many varieties available. Of particular interest is the two-speed gearhead pioneered by Bowmar Intrument. This unusual device, now available on special order from a number of sources, provides either of two gear ratios, depending upon the excitation of an internal clutching device. Thus a low reduction may provide high speed slewing in one mode, while a high reduction permits slow accurate tracking under heavy load in the other mode. Depending upon the nature of the package, a similar multi-mode operation may be achieved by combining clutches and gearing as shown for example in Fig. 10.

In the design of a miniature servomechanism package, substantial simplification and saving in design time can be achieved by employing an integral motor-gearhead combination. Such items as anti-backlash gearing and slip clutches are readily incorporated in the gearhead assembly, with the gearhead housing serving as dust cover. When large quantities of servo packages are contemplated, it is probably much cheaper to incorporate all the gearing in a gearbox built between two (or sometimes 3) jig-bored plates.

SYNCHROS

Synchros are currently in practical use in size 8 frames for miniature 400 cps packages; (some size 5 units are available). Typical accuracy is 7 minutes. Large leading phase shifts occur in these small sizes. Recent trends in higher frequency circuitry, around 1600 eps perhaps, may lead to increasing popularity of these sizes.

Miniature synchros can do high accuracy tracking when multi-speeded. In this type system, specified synchro tracking error is divided by high to low speed velocity ratio. A transfer circuit prevents zero ambiguity, and a stick-off voltage prevents 180° ambiguity of the slow speed synchro (required only when synchro speed ratio is even). Fig. 11 shows a two-speed synchro-system used for accurate transducer positioning in a packaged servomechanism. The only significant static error in this type of system arises within the gearing itself, resulting in inac-

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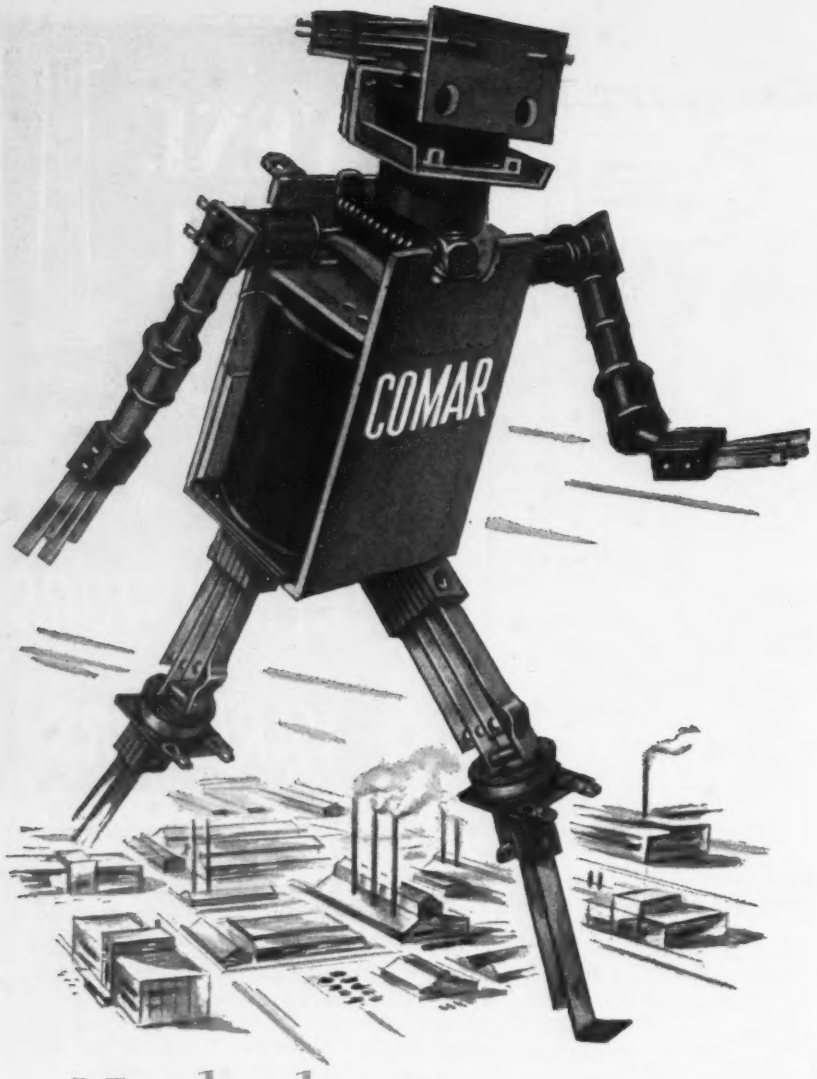

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curate correlation between high speed synchro shaft position, and the low speed (output shaft).

POTENTIOMETERS

Modern potentiometer design and manufacturing techniques have achieved high precision in very small diameters. A one inch diameter 10-turn potentiometer may have an accuracy of 0.03% as compared with approximately ten times this error in a single-turn unit. Trimming techniques and servomechanism controlled error-compensating winding devices contribute to these high accuracies. Single-turn film-type potentiometers have yielded exceptional accuracies, to 0.1% by automatic trimming of the film contour during measurement and adjustment of independent linearity.

In extremely miniature servomechanism packages, the ten-turn potentiometer rotating at relatively high speed may introduce significant friction in the closed loop. With the low torques of the size 8 and size 5 motors, the reflected friction may have significant effect on static accuracy.

MAGNETIC CLUTCHES

Magnetic clutches are playing a role in an increasing percentage of new servo package designs. They are useful in speed and direction changing, uncoupling and coupling of shafts, fast braking, and similar applications. They are also used in extremely-high-acceleration intermittent-duty actuator type devices. Driving these clutches with heavy loads so that they slip continuously should generally be avoided. Such slipping may permanently damage the clutch faces. Where it appears that slipping will occur, a special slip clutch can be inserted. Problems in dealing with magnetic clutches may be quite intricate. Friction slip clutch adjustments are obviously a function of shaft torques, which in turn depend upon shaft speeds. Sometimes an apparently suitable clutch arrangement results in gearing being driven backwards with excessive speeds and development of friction torques.

Because they are so versatile (in a sense a clutch is to mechanical "circuitry" what a switch is to electrical circuitry) a great variety of clutches

is available. These permit the most convenient packaging where a group of shafts are to be coupled and uncoupled in a specific manner. Most of these are available in package sizes down to size 5.

ADDITIONAL ELEMENTS

The major components of miniaturized servomechanisms have been briefly described above. Numerous additional items are necessary ingredients of the servo package. Among the mechanical items are limit stops which are often essential where total angular travel is finite. Limit stops incorporated within precision potentiometers often prove satisfactory. Stall torques are proportionally lower in multi-turn potentiometers, with less resulting strain on the stops.

Read out elements may include single or multi-turn dials, arrays of dials, or counters with digital read-out, lighting vernier scales and parallax.

The electrical connector, if one is required, must be chosen with care. Fortunately in miniature transistorized servomechanisms, relatively low voltages and currents occur. The connector may be hermetically sealed or not, depending upon requirements of the package. Miniaturized electrical connectors are readily available.

Other items are dust covers, seals, fastening devices, cleats, cabling and similar odds and ends. Often overlooked is the problem of cabling. Room must be available for soldering to the miniature connector, and disconnecting all screw terminals. Enough slack must be left in the cabling to permit easy disassembly of the package, and internal room should permit neat curling up of the cable wiring without danger of interference with moving parts in the assembled package.

BUYING A SERVOMECHANISM PACKAGE

Purchasing a servomechanism package from an outside vendor can be an important simplification in the overall design of a major system. The item to be purchased must be adequately defined if serious misunderstandings and blunders are to be avoided.

It must be remembered that a servomechanism package is a much more complex device than its individual components, and a purchase order must be sufficiently complete to cover all important areas. The principal areas cover,
1) the mechanical construction—how it fits as a package into the system, 2) performance, and 3) environmental and reliability factors. Table IV lists the most important items to consider when placing an order for a packaged servomechanism,

The purchase order should state precisely the specifications which the final device must meet. In the event of possible ambiguity, the exact test circuit should be prescribed. Considerable attention must be paid to new or unusual components in the design and appropriate specifications (and perhaps tests) should be called out to guarantee freedom from trouble. The same attention should be given to "tricky" mechanical assemblies devised by the vendor to meet tight space requirements.

A major purchasing distinction must be made between servo packages de-

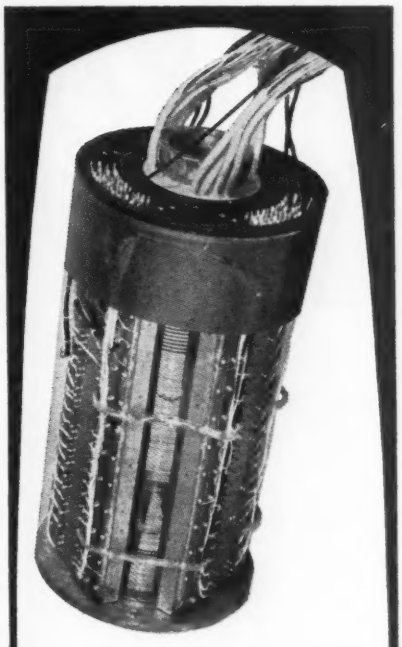
TABLE 4

Check List, Specifying Packaged Servos, Things To Check

BASIC PACKAGE REQUIREMENTS
- Standard vs special servo packages
- Choice of type of amplifier
- Is amplifier located within servo package?
- Standard and semi-standard parts vs. specials
- Power supply requirements
- Servicing and spare parts problems

EXTERNAL PHYSICAL CHARACTERSTICS
- Size requirements
- Type of construction
- Cost factors
- Type of mounting
- Electrical connectors
- Appearance factors
- Weight
- Readout requirements
- Output shaft requirements
- Pertinent specifications and standards
- Performance Requirements
- External load
- Duty cycle
- Nature of input signal, source impedance
- Nature of output signal, output impedance
- Velocity and acceleration specifications
- Static accuracy
- Dynamic accuracy
- Maximum and minimum operating speeds
- Responses to special inputs
- Bandwidth and time constants
- Damping factor
- Total angular travel

INTERNAL DESIGN CONSIDERATIONS
- Replacement of critical components
- Ease of zeroing and alignment
- Protective slip clutches
- Pinning vs. clamping of gears
- Lubrication
- Class of electrical insulation
- Precision and mesh of gear
- Special component and parts specifications
- General environment problems, military vs. non-military
- Basic type of servo
- Materials and pitch of gears



NEW SERIES of Antenna SLIP RING Assemblies

12 to 500 RINGS

A standardized line of large Slip Ring assemblies, designed for a multiplicity of instrumentation, control and power circuit applications. First production assemblies are in use on radio telescopes, radar and tracking antennas and human centrifuge installations.

Assemblies vary from 12" to 72" in length, are either shaft or flange ball-bearing mounted and may be specified with hermetically sealed housings. Noise levels are held to a minimum. So are intercircuit losses, cross-talk and radiation, through proper shielding.

For complete information, write:

SCA

SLIP RING COMPANY of AMERICA

3612 West Jefferson Blvd., Los Angeles 16, Calif.

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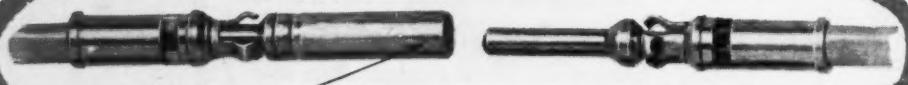
New! REMOVABLE CONTACT

BY CONTINENTAL CONNECTORS

ENLARGED VIEW TO SHOW DETAIL
OF PRECISION MADE SCREW MACHINE CONTACT



Closed Entry Cartridge completely protects socket contact against probe damage or handling inside and outside molding

Eliminate all connector soldering operations with Continental Connector's new, improved removable contact with crimp terminations. Extra wide, three-tine spring clutch on pin and socket provides maximum holding area between contact and molded block. Contacts are supplied separately and are wired independently. This permits mounting of plug and socket connector units at any convenient time without waiting for completion of wiring operation.

Wire crimping is fast and easy with hand or automatic power crimping tools readily available for small or quantity production. Contacts are quickly removed and replaced with a simple, low cost hand tool.

These removable contacts are designed for use with Continental Series 25 Miniature Rectangular connectors in sizes of 14, 26, 34, 50, 75 and 104 contacts. Both socket and pin contacts are made of phosphor bronze with gold plate over silver plate. Terminations accommodate any #16 to #22 AWG wire. Removable contact connectors are interchangeable with existing fixed contact types.

For complete technical data bulletin on Continental Removable Contact Connectors, write to Electronics Division, DeJUR-AMSCO CORPORATION, 45-01 Northern Boulevard, Long Island City 1, N. Y. (Exclusive Sales Agent.)

EASY 3-STEP PROCEDURE FOR WIRING AND INSERTION OF CONTACTS

1—CRIMPING . . . One motion with crimping tool quickly crimps contact securely to wire

2—INSERTION . . . Simple hand held insertion tool inserts crimped contact into molding

3—REMOVAL . . . Special spring-loaded removal tool removes contact and wire with one motion

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COMPONENTS DIGEST

signed by the purchaser for fabrication by the vendor and those where the vendor must do a major design job. An intermediate possibility occurs where the purchaser details a comprehensive "design plan". This may take the form of a list of standards and rules for good practice attached to the basic servomechanism specification. Often, as is common with simulator devices, a very large number of servomechanisms are required in an overall system but the total number of each specific type may be relatively small, making it necessary to establish some uniformity. In situations like this, comparison of the block diagrams of all the servomechanisms will reveal any uniformity in the arrangement of components, establishing a partial basis for standardization. Where possible the fewest types of gears should be used, so that stocking of parts is simplified. Standards may suggest a specific steel pinion and aluminum meshing gear as the basic mesh components to be used wherever possible. This can often be done with little sacrifice of system inertia or compactness.

Since the jig-bored plates constitute the heart of the servomechanism package, standard hole types and locations, and of course tolerances, should be used wherever possible. Certainly the maximum possible uniformity is required in mounting hardware, selection of components, and packaging policy.

Where servomechanism requirements are particularly intricate, it is important to pin-point the quality of individual components. Often the purchaser may specify typical units of an acceptable quality, allowing the vendor to procure his own. Pinning down too much will prevent the vendor from doing a satisfactory job, especially if he is expected to accept overall responsibility for performance. It certainly gives him a late delivery excuse if the performance is not satisfactory.

PREVIOUS COMPONENTS DIGESTS

Miniature servomechanisms depend heavily on the quality and dimensions of available components. For more complete component information, including manufacturer's data on size and performance, as well as state-of-the-art reports, consult individual Components Digests and pertinent special articles.

COMPONENTS FOR MINIATURE PACKAGES

Many companies submitted information concerning their miniature components for inclusion in the preceding digest. Since specific product information did not apply to the general nature of the digest subject, it is presented here as a useful addendum.

Motor-Generator

Size five motor generator (½" dia.) weighs one ounce and is said to perform the duties of a Size eight motor generator weighing 2¼ ounces. Smaller power supplies and smaller servo amplifiers may be used with the unit. Its lower temperature rise means a decrease in insulation and heat sinks. Also available is a Size five gear head with ratios of 30:1, 70:1, 160:1, and 375:1. Daystrom, Inc., Transicoil Div., Worcester, Pa.

Write No. 315 in Box on Inquiry Card

Synchronous Motor

Three pound permanent magnet ac motor provides constant, 72 rpm synchronous, speed and/or dc stepping with instant starting, stopping or reversing. Input ratings are 120 volts, 40/70 cycles, one phase, 0.30 amp maximum current (at 60 cycles) and output torque is 50 oz.-in. Class B insulation is used and the unit is rated for 75°C temp. rise from 40°C maximum ambient under continuous duty. Superior Electric Co., Bristol, Conn.

Write No. 316 in Box on Inquiry Card

Dynamic Bearing

An electromagnetically-powered ball bearing assembly with extremely low restraining torque characteristics consists of a bearing within a bearing. The outer ring of the sensitive inner bearing is oscillated by a built-in electromagnetic drive. This action tends to cancel out the friction torque resisting the rotation of the supported member. Under preload, torque increases only slightly and starting torque is the same low value as running torque. Barden Corp., Danbury, Conn.

Write No. 317 in Box on Inquiry Card

Transformers

Maximum base area of transformers is 0.310 by 0.410 inches. They incorporate 0.020 inch dia. nickel alloy leads located at standard 1/10 inch grid space for printed circuit boards. A small base mounting pad has been designed into the units, which are rated at 50 milliwatts at 300 cps, to slightly raise

BASIC BUILDING BLOCKS FROM KEARFOTT

FREE GYRO

A highly reliable, two-degree-of-freedom instrument utilizing AC synchros at each gimbal axis. Designed to operate under the most severe missile conditions, this gyro has AC torquers mounted at each gimbal axis to permit command positioning or slaving of spin axis to desired reference position; each torquer capable of producing a precession rate of 360°/minute with 12.5 watts/phase power input.

TYPICAL CHARACTERISTICS = Q2315

Environmental Capabilities
Temperature Range
(operative): −54°C to +71°C
(non-operative): −65°C to +85°C
Altitude: Unlimited
Vibration: 10g, 10-2000cps

Pickoffs
Excitation:
26V, 400 cps, single phase
Output (sinusoidal):
11.8V ± 5% max.
Error from E.Z.: 10 min. max.

Motor
Excitation:
115V, 400 cps, three phase
Speed: 23,500 RPM
Momentum:
2.25 x 10⁶ gm cm²/sec.

Caging and Preset Provision
(Electrically energized torquer type)
Excitation: 115V max./phase
Torquer Constant:
22.8 dyne cm/Volt²

Performance Characteristics
Free Drift:
0.5°/minute each axis
Runup Time:
1 minute max.
Torquing Rate:
360°/min. (intermittent)
40°/min. (continuous)

Physical Features
Dimensions: 4" dia. x 5¾₆" long
Weight: 5.5 lbs. (approx.)

Write for complete data.

KEARFOTT DIVISION
GENERAL PRECISION, INC.
Little Falls, New Jersey

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the transformer permitting inspection of all solder joints. Triad Transformer Corp., Venice, Calif.

Write No. 318 in Box on Inquiry Card

Computer Module

Dice-sized sub-module is said to be the most compact circuit unit ever designed for off-the-shelf electronic components. The ½ inch cube modules, each holding anywhere from 12 to 18 components, weighs only two grams and is suitable for use in any all-purpose digital computer. It has a packing density of a quarter of a million parts per cubic foot. Units are arranged on modular "cards" at a rate of 44-50 per card, which can be stacked on top of one another to conserve space. The module is encapsulated, eliminating hot spots. Silicone semiconductor components are used in the module circuits in a temperature range of −70°F to +240° F and can withstand a thermal shock of 100 degrees per minute. Republic Aviation Corp., Farmingdale, L.I., N.Y.

Write No. 319 in Box on Inquiry Card

Cartridge Heater

Designed for applications where space is limited and heat requirements are high, ⅛" dia. cartridge heaters operate at maximum surface temperatures up to 1250°F. Heating wire is situated close to the outside surface for maximum heat transfer and minimum internal temperature while preserving good dielectric qualities. Units can also be used as high temperature resistors, supplying up to 50 watts per sq. inch maximum density. Hotwatt, Inc., Danvers, Mass.

Write No. 320 in Box on Inquiry Card

Rack Cooling

Pontoon base blower is designed for installation under the standard modular electronic cabinet to permit more rack space for instruments and components. Units employ centrifugal blowers to supply cool, filtered air ventilation throughout the entire rack. Single phase, 115 volt, 60 cycle equipment is supplied as standard with motors meeting mil specs. McLean Engineering Lab., Princeton, N.J.

Write No. 330 in Box on Inquiry Card

Capacitors

Measuring 0.075 by 0.250 inches over the insulation sleeving, porous-anode capacitors retain 85% of their room temp. capacitance at −55°C. Rated at 50 volts, 1 microfarad, the units perform at 15G's, 2000 cycles per second. At −55°C, its nominal impedance is 1600 ohms. G.E., Schenectady, N.Y.

Write No. 321 in Box on Inquiry Card

Resistors

Recommended where economy and compactness are of major importance, resistors are made of a wire wound fibre glass core to which lead and clip assemblies are securely crimped. Unit is in a ceramic enclosure which is filled with a silicone base cement providing protection against moisture. Tru-Ohm Prod., Chicago, Ill.

Write No. 322 in Box on Inquiry Card

Pressure Transducers

Designed to be easily stacked for maximum use of space, absolute, gage and differential pressure transducers provide the performance, accuracy and economy of unbonded strain gages. Compensated temp. range is −65°F to +250°F with ambient temp. limits of 100°F to +275°F. Non-linearity and hysteresis is less than ±0.75% of full scale output. Weight for each unit is approximately 4 ounces. Statham Inst. Inc., L.A., Calif.

Write No. 323 in Box on Inquiry Card

Shift-Register Elements

Measuring approximately 1/10 cu. in., an epoxy-encapsulated package containing a complete one-bit shift register circuit makes possible construction of shift registers with a theoretical packing density of 50,000 components/ cu. ft. Unit requires less than 150 mw peak power to advance (shift) a "1" signal from stage to stage of the resister. One 200 mw transistor will drive up to 20 register bits. Output signal amplitude and waveform is independent of the advance-current (shift-pulse) width over wide ranges making overdrive the memory core. Magnetics Research Co., White Plains, N.Y.

Write No. 324 in Box on Inquiry Card

Printed Circuit Boards

Printed circuits, designed in many layers and laminated together under heat and pressure can be used to perform such complex interconnections as the miniaturized replacement for cumbersome back panel wiring in computers. Other uses include many switching and coding applications. A typical 6-layered printed circuit sandwich measures 0.026 in. in thickness. Photocircuits Corp., Glen Cove, N.Y.

Write No. 325 in Box on Inquiry Card

Differential Pressure Transducers

Highly accurate for use in extreme environmental conditions, measures 1¼" square by 4½" long and weighs 16 oz. Available in 16 pressure ranges between ±300 psia and ±5000 psia, the transducers operate in the temp. range from −65°C to +125°C, with case pressures to 10,000 psia. Units are said to have maximum of 1% linearity error, ½% friction error, ½% error from hysteresis effects and 1% vibration error when subjected to 35g vibration at 2000 cps. Response time is 25 millisec for 63% of applied step. Servonic Inst. Inc., Costa Mesa, Calif.

Write No. 326 in Box on Inquiry Card

Torque Motors

Electromechanical actuators are said to have the highest performance per weight ratio available. Unitized construction eliminates such problems as pole pieces or magnets shifting position or breaking away from the assembly due to shock or vibration. Strokes of ±0.006, ±0.007, ±0.008 or ±0.015 inches are available. Servotronics Inc., Buffalo, N.Y.

Write No. 327 in Box on Inquiry Card

Ceramic Capacitors

Designed for general applications in bypass-coupling, filtering and blocking circuits, rolled ceramic capacitors offer good electrical characteristics for critical applications in decoupling and pulse circuits where low series resistance at high frequencies together with small sizes are required. Available in capacitances from 0.1, to 2.0 mfd. at 100 vdcw for operation at temps. between −55°C to +85°C. Derated to 50 vdcw they will operate at temps. as high as 125°C. Units meet or surpass Mil-C-11015B. Aerovox Corp., Olean, N.Y.

Write No. 328 in Box on Inquiry Card

Digital Encoder

Completely transistorized for minimum size and maximum reliability, 12-bit binary encoder performs to an accuracy of ±1 millivolt in 65 microseconds over the temp. range of −55° to +70°C. Units meet Mil-E-5400B and Mil-E-005272. Packard Bell Computer Corp., L.A., Calif.

Write No. 334 in Box on Inquiry Card

Coaxial Thermocouple

Thermocouples, 0.0062" in dia., as reliable as standard sized thermocouples, offer extremely low thermal inertia and permit probing into exact and normally inaccessible locations. Construction is a copper tube drawn over a constantan wire with heat resistant insulation which will not melt or exhibit dielectric breakdown under 3000°F between them. Uniform Tubes, Inc., Collegeville, Pa.

Write No. 329 in Box on Inquiry Card

Load Indicator

Requires only 8¾ inches of vertical rack space to readout six strain gage load cells. Each of the six inputs has its own zero and span control so that each load cell can be zeroed and its span adjusted independently of the others. Power is applied continuously to load cells so they will always be stabilized and ready to be read. A selector switch permits rapid change from one cell to another during a test. Performance Measurements Co., Detroit, Mich.

Write No. 332 in Box on Inquiry Card

Delay Lines

Unique network and construction techniques plus the use of subminiature toroidal inductors and disc capacitors permitted development of delay lines with the high density of 200 lumped constant sections per cubic inch. Units with delays of 0.1 to 20 microseconds, 100 to 2000 ohms impedance, 100 to 1 delay to rise time ratios and attenuations as low as 0.008 db are available. Valor Instruments, Inc., Gardena, Calif.

Write No. 333 in Box on Inquiry Card

Sequence Programmer

Solenoid actuated switching device, designed for operation with solid state circuitry over a wide range of input rates, employs an interchangeable coded disc to determine or sense the sequence of events. Highly precise indexing action permits division of the program disc for sequences requiring up to 100 switch positions. The complete programmer is less than 1¾" long and weighs 0.9 oz. Unit is rated for 4 to 8 volts and operates with input pulses as short as 11 milliseconds. Environmentals cover a temp. range from −40° to 165°F, vibration at 10g from 5 to 55 cps and shock at 15g-11ms in accordance with Mil-E-5272. Elgin Micronics, Elgin, Ill.

Write No. 335 in Box on Inquiry Card

Logic Network

Balanced resistor network, measuring 1¼ x 11/16 x ¼ inches, contains five precision wire wound resistors and one transistor incorporated into a NOR logic circuit. Complete circuit, encapsulated in a rigid epoxy compound, withstands tough moisture, temperature cycling, vibration and life tests. Termination is designed for printed circuit or plug mounting. Dale Prod. Inc., Columbus, Nebraska.

Write No. 336 in Box on Inquiry Card

Synchronous Motors

Epoxy encapsulated hysteresis-synchronous motor, 1¼ in. in dia., develops ¾ oz. inches of torque at 1800 rpm synchronous speed, and is normally wound for 110 volt ac, 60 cps. Although designed for industrial uses, the units are equal to precision military motors of comparable size in performance. Mounting is by clamp around motor O.D. Recommended for use in miniaturized recorders, timers, computers, etc. Overall size is 1¼ in. dia. by 2½ in. long; weight is 7 oz. Globe Ind., Inc., Dayton, Ohio

Write No. 337 in Box on Inquiry Card

Binary Encoder

Packaged in a standard size 8 casing, measuring 0.75 in. in dia. by 1.25 in. in length, a 13-bit analog-to-digital converter has a resolution of 128 counts per input shaft revolution and a total capacity of 8192 binary counts. Combination of two cascaded discs and 25 contact pickups provide serial or parallel binary readout representing shaft position or rotation. Accuracy can never be less than the least significant bit in 2^{13} counts. Counting speeds range from 0 to 200 rpm and tests indicate a potential life of 2×10^6 revolutions at 200 rpm. Librascope, Glendale, Calif.

Write No. 338 in Box on Inquiry Card

Sealed Switch

Measuring 0.616 x 0.6 x 0.316 in. and weighing only 0.2 oz., a single-pole, double throw switch combines miniaturization with reliability. Switch mechanism and extending leadwires are imbedded in an epoxy resin inside a treated corrosion-resistant aluminum housing. An elastomer seal around the plunger prevents dust, dirt or moisture from entering. Ambient temperatures range from −65° to 230°F and electrical rating is 4 amps inductive at 28 volts dc; 5 amps at 115/230 volt 60 cycle ac. Minn.-Honeywell Reg. Co., Freeport, Ill.

Write No. 339 in Box on Inquiry Card

BASIC BUILDING BLOCKS FROM KEARFOTT

SIZE 11 SYNCHRONOUS MOTOR

Featuring pull out torque efficiency of 50% nominal with 3.4 watts input and 3 watts pull out power, this synchronous motor represents a major achievement in terms of performance for a unit of this extremely small size. Additional advantages made possible by Kearfott's unique design include resistance to environmental extremes, light weight construction and low unit cost. This motor and its variations are available in production quantities.

TYPICAL CHARACTERISTICS R172

Excitation:	Phase 1	Phase 2
Voltage	40V	40V
Frequency	400 CPS	400 CPS
Power	2.3 Watts	2.3 Watts
Current	0.157 Amps	0.157 Amps

Performance:

Synchronous Speed	8000 RPM
Stall Torque	0.2 In. Oz.
Pull Out Torque	0.35 In. Oz.
Pull In Torque	0.15 In. Oz.

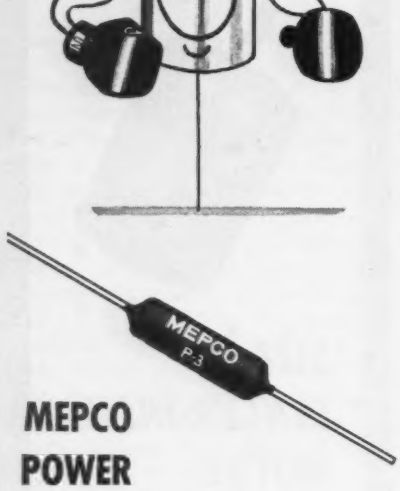
Write for complete data.

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE NO. 81 ON INQUIRY CARD

POWERFUL



MEPCO POWER WIREWOUND RESISTORS

- Six wattage ratings — 2.5 watt through 15 watt
- MIL-R-26C Styles RW55, RW56, RW57, RW58 and RW59 to Characteristic G
- Resistance range .15 ohm to 105K according to style
- Tolerance: 1% Standard. .1% to 5% special
- Protection: Multiple coats of baked silicone resin
- Dielectric 1000 V RMS min.
- Leads: 1½" Long, #18 AWG hot solder coated

MEPCO INC.
MORRISTOWN, N. J.

CIRCLE NO. 82 ON INQUIRY CARD

COMPONENTS DIGEST

Variable Resistors

Linear motion variable resistors exhibit no contact bounce when subjected to vibration tests of 20-2000 cps at 30 g's for 10 minutes in each of three planes. Resistance range is 100 ohms to 20K ohms (wirebound) and 10K ohms to 2.5 megohms (composition). Nine units can be packed in a cubic in. Centralab, Milwaukee, Wisc.

Write No. 340 in Box on Inquiry Card

Nylon Clutch/Gear

Clutch, 1 in. dia., made of nylon and steel alloy has a minimum torque rating of 10 oz./in. and operates in a temp. range of –60 to +85 C. Unit is driven by a nylon, precision molded bevel gear designed so as to permit the driving of several units by a single servo motor. The ¼ in. bore and threaded slip ring make the clutch particularly adaptable for driving potentiometers. Altair Rsch. & Mfg. Co., Baldwin Park, Calif.

Write No. 341 in Box on Inquiry Card

Servovalves

High performance electrohydraulic servovalve, weighing 5.12 oz., uses a small second stage spool and bushing contained in a lightweight aluminum body. Maximum flow capacity is 3 gpm at 3000 psi. Standard mountings allow the units to be used interchangeably with servovalves on existing systems and test equipment. For new applications, smaller mountings are available. MOOG Servocontrols, Inc., East Aurora, N.Y.

Write No. 342 in Box on Inquiry Card

Pressure Switches

Lightweight pressure switches, weighing two oz. and measuring 1 1/16 in. in dia., and 2½ in. in length, operate at any fixed pressure between 5 and 1000 lbs. per sq. in. Unlocking and turning the electrical receptacle adjusts the operating point of any unit. Operating temp. range is from –65° to 275°F. Switches meet the environmental and vibration requirements (extended to 2000 cycles per sec.) of Mil-E-5272A (procedure I) and withstand shocks up to 100 g's. Consol. Controls Corp., Bethel, Conn.

Write No. 345 in Box on Inquiry Card

Storage Tube

Iatron, a 2½ in. storage cathode-ray tube, is said to be the brightest, lightest and smallest of its type. Used as a panel-mounted radar or infrared indicator in aircraft, its fast writing and high deflection speed permits accurate and instantaneous presentations. A special coaxial electron gun system eliminates trapezoidal distortion of the scanning pattern. Full daylight viewing of electrical signals by image intensification is possible and a display exceeding 4000 foot-lamberts brightness is obtained at a phosphor voltage of only 8.5 kv. The tube meets all the environmental requirements of Mil-E-5400. ITT Labs., Fort Wayne, Ind.

Write No. 346 in Box on Inquiry Card

Thermal Relays

Low-current firing thermal relays protect transistors and other solid-state devices. Operation is based on the fuse burnout principle. In addition to overload protection, the unit can be used as a low-current sensing device. Glass housing provides interior visibility plus resistance to heat and shade. Networks Electronic Corp., Van Nuys, Cal.

Write No. 347 in Box on Inquiry Card

Pressure Transducers

Sensing element of lightweight pressure transducers is a precision No-Span-C Bourdon tube which, with a balanced mechanical system, provides temperature stability of 0.01%/F° over a range from –65°F to 350°F. Other characteristics include maximum change for 10 g to 2000 cycles of vibration and 1% maximum shift at 50g's of acceleration and the units meet Mil-E-005272-B for shock. Power rating is 0.7 watts at 70 F and pressure range varies from 0-100 psig to 0-5,000 psig. Unit measures ⅞ x 1¾ in. and weighs 3.5 oz. Internat. Resistance Co., Phila, Pa.

Write No. 343 in Box on Inquiry Card

Resistance Thermometers

The heart of a 0.156" dia., 0.281" long thermometer is a non-inductively wound chemically-pure platinum wire sensing element housed in a cylindrical stainless steel case and potted for environmental capabilities, dielectric and mechanical strength. Output is approximately 1 ohm per degree F, and impedance is 470 ohms at 32°F. Minco Prod. Inc., Minneapolis, Minn.

Write No. 348 in Box on Inquiry Card

Solenoid Valves

2 oz., 3 way valves are designed for 235 psi operation with 0.035 equivalent orifice at −65° to +165°F temperatures. Internal construction provides essentially zero leakage for air. Coil can be made submersible and configuration can include a piped vent and/or electrical connector. Eckel Valve Co., San Fernando, Calif.

Write No. 349 in Box on Inquiry Card

Print Counter

Impulse counter that prints as well as indicates, measures 2⅞" x 5⅝" x 7 3/16". The 6 digit device provides on paper tape, a permanent record of the count at any given moment. Printing and resetting commands may be given either from a remote location or by push buttons provided on the front plate of the counter. Landis & Gyr, Inc., N.Y.C.

Write No. 350 in Box on Inquiry Card

Microminiature Rivets

Fasteners for subminiature electronic and instrument needs combine the required characteristics of precision, reliability and performance with ease of installation. The head form is a modified brazier with low contour and minimum functional diameter for the stresses imposed. The design combines advantages of both solid and tubular rivet styles in a concentrically deep drilled shank, providing the ease of setting essential in small or delicate assemblies. Solid upper portion of the rivet contributes rigidity and prevents buckling or bending in the upsetting or clinching operation. Drilled section accomplishes an effective clinch with a minimum of pressure on the parts or material being assembled. Circon Component Corp., Goleta, Calif.

Write No. 351 in Box on Inquiry Card

Pressure Transducer

13 oz. pressure transducer is primarily designed for airborne applications where precise measurements of 0.25% accuracy are required over a wide temp. range. The measuring element is a one piece Ni-Span-C proving ring to which are bonded 4 precision strain gages, forming a Wheatstone bridge. When the transducer is subjected to zero gravity conditions the ring acts as a heat sink and conducts heat from the resistance wires to the instrument case. Application of 3 times the rated full scale pressure will not damage the instrument or necessitate recalibration. Taber Instr. Corp., N. Tonawanda, N.Y.

Write No. 354 in Box on Inquiry Card

Trimming Pots

Height of 0.195 in. above a printed circuit board for trimming potentiometers makes them particularly useful in applications that require stacking boards together into modular assemblies. A long and precise winding used in the units produces maximum resistance and fine resolution. Use of a worm-gear adjusting device provides high-friction loading insuring subtle adjustment and eliminating backlash. High power ratings are available over wide temperature ranges. Daystrom Inc., L.A., Calif.

Write No. 352 in Box on Inquiry Card

Latching Relay

Magnetic latching relay, weighing 1.1 oz., permits contact loads from dry circuit conditions to 10 amps. Unit withstands rugged environments, meeting Mil-R-5757C and Mil-R-25018. Babcock Relays, Inc., Costa Mesta, Calif.

Write No. 355 in Box on Inquiry Card

Positive Disc Clutch

Designed for instrument applications, disc clutches are 1½" in dia. and ¾" in overall length. Positive acting crown teeth are magnetically engaged, spring released and are pitched for easy engagement at very low rpm. Unit develops 80 oz. in. torque and may be wound for 28 volts d-c. Stearns Elec. Corp., Milwaukee, Wisc.

Write No. 353 in Box on Inquiry Card

Polarized Motor

High starting and running torque motor has a near constant current consumption under locked rotor or load variation conditions. Specs include: 4 in.-lb. starting torque, 8 in.-lb. running torque at 1 rpm, weight of 12 oz., 1⅜ in. dia. by 2¼ long (includes internal gears and internal solid state commutation). Cook Elec. Co., Chicago, Ill.

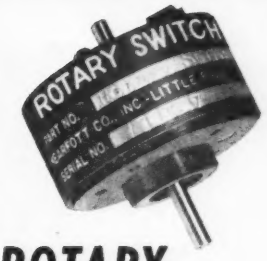
Write No. 344 in Box on Inquiry Card

Trimmer Potentiometers

Six trimmer potentiometers, ⅞" in dia., are available in eight standard resistance values from 100 ohms to 25,000 ohms. Units can dissipate one watt at 125°C (derated to zero at 150°C) for a period of at least 2000 hours. All models meet the environmental requirements of Mil-STD-202A and NAS710. Carter Mfg. Corp., Hudson, Mass.

Write No. 331 in Box on Inquiry Card

BASIC BUILDING BLOCKS FROM KEARFOTT



ROTARY SWITCH

Kearfott's rotary switching devices for missile and aircraft systems are used to sequence or switch circuitry as a function of time or shaft position. Used in conjunction with sensitive relays or solid state switching techniques, high current loads can be handled. These switches consist primarily of shaft assembly and bearing mounted cylinder divided into conducting and non-conducting segments with continuous track for common input. Multiple conductor "broom" type brushes ride on each cylinder track while number of tracks and segmentation of each is function of the number of circuits and type of "on-off" sequencing required.

TYPICAL CHARACTERISTICS P1280-11A

Number of switching tracks: 2

Angular Segmentation (both referenced to 0° start):
Track 1 — Non-conducting about 0° + 50°
Track 2—Conducting 0° -180°
Non-conducting 180° -0°

Mechanical Accuracy of Segmentation:
±1° (better as required)

Starting and Running Torque:
0.1 oz.-in.

Current Capacity:
50 ma at 28V/Brush (suitable for any sensitive relay or solid state switching circuits)

Write for complete data.

KEARFOTT DIVISION
GENERAL PRECISION, INC.

Little Falls, New Jersey

CIRCLE NO. 83 ON INQUIRY CARD

The new 20 watt DIEHL† Instrument Servomotor a study in practical design

A carefully constructed winding—set in a round, die cast aluminum housing and totally encapsulated with a protective epoxy resin . . . a low inertia ingot-iron rotor . . . and two sets of prelubricated ball bearings . . . a simple anatomy. Yet these few simple parts combine to make the new 20 watt DIEHL Instrument Servomotor the most practical servomotor ever designed for commercial applications . . . because all costly construction features and environmental precautions which are unwarranted in a commercial application have been eliminated. But full performance and all essential environmental precautions have been retained . . . including moisture, salt, and fungus proofing, good resistance to shock, safe operation in ambients of −55 to +55°C, and these other outstanding performance characteristics:

SPECIFICATIONS AT STALL

Cat. No.	FPE49L-116-1
Output	20 Watts
Voltage (per phase)	115 Volts
Frequency	60 Cycles
Torque	25 oz. in.
Input power (per phase)	54 watts
Control phase impedance	174 ohms
No Load Speed	3500 R.P.M.
Inertia (Wk2)	.725 oz. in.^{2}
Theor. acceleration	13,300 rad/sec.^{2}
Weight	2.75 lbs.
Motor Transfer Function	$\frac{3.2}{S\ (.028S + 1}$
Frequency response	5.75 cyc./sec

Write for more information on our complete line of instrument servomotors. Available in sizes 11 and 15, power ratings from 1 to 20 watts.

Diehl†

DIEHL MANUFACTURING COMPANY

A SUBSIDIARY OF THE SINGER MANUFACTURING COMPANY

Somerville, New Jersey

SINGER*

†A Trademark of THE DIEHL MANUFACTURING COMPANY *A Trademark of THE SINGER MANUFACTURING COMPANY

CIRCLE NO. 60 ON INQUIRY CARD

WORTH FILING

Molybdenum

Details on the various sizes, forms, conditions of use, tolerances, weights, and methods of identification of molybdenum and molybdenum-base alloys are given in a 24 page booklet. Climax Molybdenum Co., N.Y., N.Y.

Write No. 519 in Box on Inquiry Card

Transformers

36 pages provide complete product specs on over 550 units for military, industrial and communications applications. Included among hermetically sealed transformers and filter reactors meeting MIL-T-27A, are 400 cycle, ultraminiature transistor transformers. Chicago, Ill.

Write No. 520 in Box on Inquiry Card

Ferrite Devices

Electrical characteristics and over-all length for more than 60 models of coaxial isolators, broadband and special-purpose waveguide isolators, compact "Tee" circulators and phase-shift circulators are listed. Typical unit is an octave S-band isolator capable of 15 db isolation with 1 db insertion loss and 1.2 VSWR. Sylvania Elec. Corp., N.Y., N.Y.

Write No. 521 in Box on Inquiry Card

Fasteners

24 pages cover a wide variety of tension and featherweight fasteners, self-broaching and self-sizing fasteners, pull-thru blind rivets, friction lock self-plugging blind rivets, and lock-spindle, self-plugging blind rivets. Driving cycles, strength data, grip ranges, hole size recommendations and other information is included. Huck Mfg. Co., Detroit, Mich.

Write No. 522 in Box on Inquiry Card

Variable Speed Pulleys

A full line of variable speed pulleys plus related equipment including compound drives, motor bases and frames, wide V-belts and sheaves, are described in a new 24 page technical catalog. Information includes selection and operating data, horsepower, ratings, dimensions and representative applications for a wide variety of models. The variable speed pulleys are the cam-operated type which positively maintain desired speed even under overload conditions. The units range from fractional to 5 hp. with speed ratios from 1.75 to 2.6-1.

Source: Lovejoy Flexible Coupling Co., Chicago, Illinois

For your copy: Write No. 518 on Inquiry Card

KEARFOTT developed

and now produces

precision floated gyros

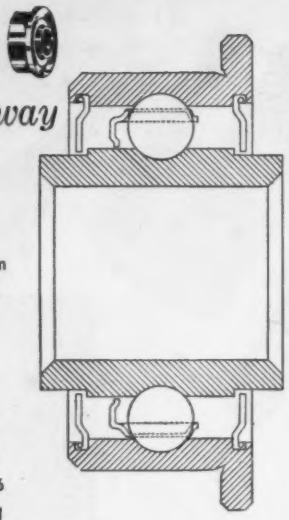
for the

Atlas missile.

Engineers: *Kearfott offers challenging opportunities in advanced component and system development.*

KEARFOTT DIVISION *Little Falls, New Jersey* **GENERAL PRECISION, INC.**

CIRCLE NO. 84 ON INQUIRY CARD



Now — do away with bosses!

Being revolutionary is routine with MPB miniature bearings. Used in gear trains, MPB extended inner ring bearings eliminate gears with bosses. For details about extended inner ring bearings — or any of MPB's 500 types and sizes — write to MPB, Inc., 1306 Precision Park, Keene, N.H

MINIATURE PRECISION BEARINGS INC.

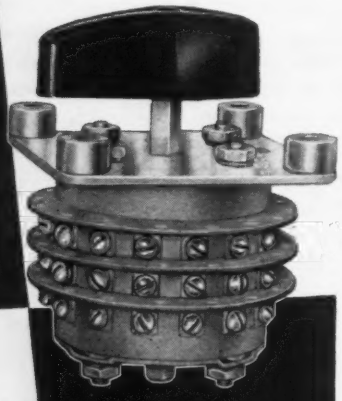
MPB

Helps you perform miracles in miniaturization

CIRCLE NO. 86 ON INQUIRY CARD

TYPE **JK**

ROTARY SWITCH manufactured in accordance with MIL-S-21604 and BuShips Drawing Number 815-1853013.



Sections and rotors molded of MAI-60 per MIL-M-14E.

ESCO Type JK rotary switch provides unlimited rotation in both directions.

Movement can be limited to any number of 16 positions.

Electrical rating: up to 5 amperes, 125 volts a-c.

Write for Bulletin No. 19

ESCO of WEYMOUTH

ELECTRO SWITCH CORP.

Weymouth (Boston 88), Massachusetts

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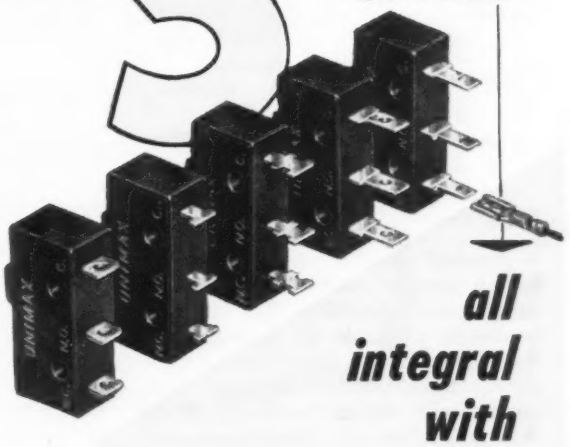
UNIMAX SUBMINIATURE SWITCHES

now in 5 TERMINAL STYLES



all integral with switch contacts

Flat, tinned lug with .058-inch hole. Just hook in end of wire, then solder.

Single-turret lug; made flat so wire won't slide around in assembly for soldering.

Double-turret flat lug — allows use of terminal as junction point.

Printed-circuit terminal; has hole for connecting component leads beneath wiring board.

Quick-Connect male terminal for snap-on wiring.

Write for catalog that gives details of UNIMAX subminiature switches.

UNIMAX SWITCH
Division, The W. L. Maxson Corporation
IVES ROAD, WALLINGFORD, CONNECTICUT

CIRCLE NO. 87 ON INQUIRY CARD

New Electromechanical Components For Electromechanical Systems

Clutches and Brakes

Magnetic design in clutches and brakes is such that it does not load the bearings, resulting in low breakaway torque and long life. Torque ratings range from 6 in. oz. (size 5) to 224 in. oz. (size 18). Power consumption ranges from 2.5 to 5 watts.
Units meet all applicable military environmental tests and may be wound with Teflon to achieve high performance under Class H temperatures. Dynamic Instrument Corp., Westbury, L.I., New York.

Write No. 307 in Box on Inquiry Card

Tape Reader

A punched tape reader with a companion spooler mechanism is said to afford greater flexibility than has been heretofore available in equipment of this class and at a lower cost. A completely transistorized electronic readout system is included with output signals compatible with most data processing systems. Reading speeds up to 200 characters per second are possible with the spooler, which accommodates paper or mylar tape up to 1 inch in width on 8 inch diameter reels. Without the spooler, the reader is capable of reading at rates up to 1000 characters per second and stop on a "STOP" character. Potter Instrument Company, Inc., Plainview, New York.

Write No. 462 in Box on Inquiry Card

Instrument Switch

Total resistance of a high-precision instrument switch is only .7 milliohms and remains constant to ±20 micro ohms. Unit is intended primarily for use on instruments measuring electrical potential and resistance. Settings are precisely located by a specially designed "click" mechanism consisting of two ball-bearings pressed against the moving end plate by parallel leaf springs. The Ealing Corporation, Cambridge 38, Mass.

Write No. 308 in Box on Inquiry Card

Synchronous Differential

Two hysteresis synchronous motors and a mechanical differential are all within the same 3 45/64" housing. One synchronous motor is connected to the control or master frequency and the other is connected to the supply which is to be controlled. Where the two frequencies synchronize, the output shaft of the device remains stationary. As one frequency changes with respect to the other, the output shaft rotates at a speed equal to one-half the difference in speed of the two motors. Applications include automatic synchronization of machinery or the frequency regulation of two supplies. Kollsman Motor Corp., Dublin, Pa.

Write No. 306 in Box on Inquiry Card

Time Delay Relay

Isolated switching contacts, voltage and temperature compensation and instant recycling are some of the advantages of a new time delay relay that meets airborne and missile application requirements. The relay resets the instant it is deenergized giving the same time delay period for each succeeding cycle. Design employs a special thermal element in conjunction with a pair of magnetic relays that utilizes the heating and cooling intervals to obtain the total time delay period. Voltage compensation is provided for operation on 22 to 32 volts d-c and temperature compensation is over the range of −65° C to +125° C. Unit may be operated under high shock and vibration. Curtiss-Wright Corp., West Caldwell, N. J.

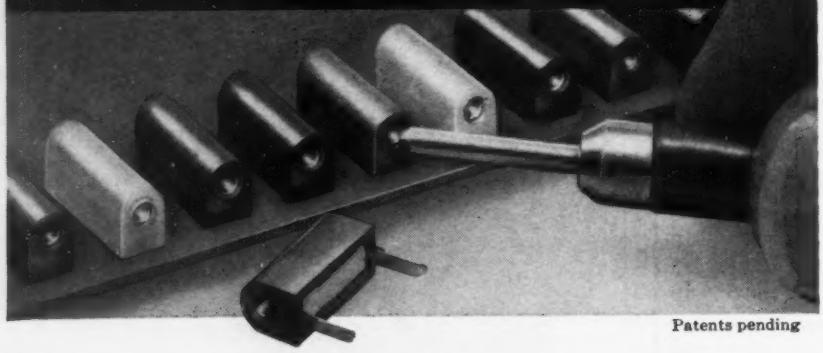
Write No. 463 in Box on Inquiry Card

Rate Gyro

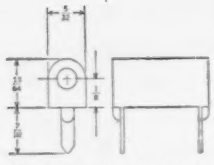
Six-ounce rate gyro provides constant damping without heaters and is said to do the work of a standard two-pound gyro in many applications. The high degree of reliability is achieved through use of a quadrilever spring. Damping is accomplished by the positive-displacement technique. Metallic paddles attached to the gimbal displace silicone fluid through flow gaps. The variation in the viscosity of the damping fluid with temperature is compensated by a change in a gap area, thus maintaining a constant damping ratio. Gimbal assembly, hermetically sealed and helium filled, is supported by a tungsten carbide pivot in a sapphire at one end, with a quadrilever spring supporting and torsionally restraining the assembly at the other end. Minneapolis-Honeywell Regulator Co., Boston, Mass.

Write No. 304 in Box on Inquiry Card

CHECK THE LOW COST of these new printed circuit test jacks



Patents pending



For .052 application holes on .400 centers

Samples on request

Ucinite's new test jack is designed for permanent, soldered assembly to printed circuit boards. Gold-over-silver-plated beryllium copper contacts provide low-resistance contact for repeated insertions of standard .080" diameter test probes. Nylon bodies are available in eleven standard code colors. Uniquely simplified construction affords economical usage in all quantities. Immediate shipments from stock.

ELECTRICAL DOT ASSEMBLIES

The UCINITE COMPANY
Division of UNITED-CARR Fastener Corporation
Newtonville 60, Massachusetts

CIRCLE NO. 74 ON INQUIRY CARD

Coaxial Latching Switch

Solenoid actuated coaxial latching switches require no holding power; operate from 28 and draw only 3.2 microamperes per hr, switching time of 10 milliseconds, frequency range extends to 11 KMC with typical specifications at 7 KMC of VSWR 1.4, insertion loss .4 db and crosstalk 30 db. Transco Products, Inc., Los Angeles 25, Calif.

Write No. 301 in Box on Inquiry Card

Events Indicator

Designed to meet critical environmental and reliability requirements, a light weight, miniaturized events indicator electrically activates at 115 vac, 400 cps. Unit draws only 1 watt, weighs only 1.3 ounces and is .680″ in diameter by 1.420″ long. It meets or exceeds all requirements of Mil-E-5272-B. Instrument dial records 1,000 events in one event increments and any event which is either initiated or indicated electrically can be registered. Thus, temperature, pressure or acceleration as well as direct on-off events can be counted. Elgin Micronics, Elgin, Ill.

Write No. 311 in Box on Inquiry Card

Centrifugal Governors

Based on differential measurement between known input speed and speed to be detected, centrifugal governors accurately detect speeds as low as ½ of 1 rpm. Designated the co-rater, the unit is recommended for processing equipment, automated systems and special low speed military applications. In addition, the co-rater can automatically control drum speeds in computers. Individual speed detector operates on speed alone, independently of voltage, load or other environmental factors. Units are virtually frictionless in operation with a service life to 1,500,000 cycles. Torq Engineered Products, Inc., Bedford, Ohio.

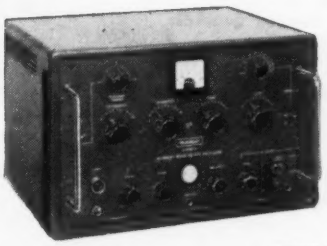
Write No. 312 in Box on Inquiry Card

Printed Circuit Motors

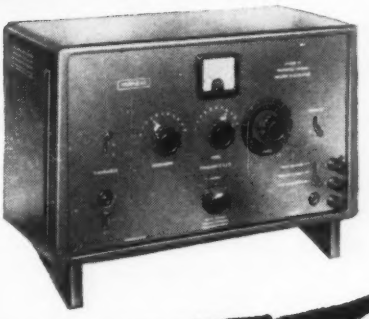
Smooth torque at low speeds coupled with extremely low armature inertia allow printed circuit motors to be used for direct drive in servo applications without gear trains. Tested at a slow speed of one hundredth part of a revolution per minute, the motor showed no clogging or jerking. Low armature inductance, not exceeding a few microhenries, eliminates the sparking normally associated with commutating. Two sizes of servo motors are available: 4¾″ in diameter and 2¾″ in length and a larger model 5⅝″ in diameter and 3″ in length. Photocircuits Corp., Glen Cove, N.Y.

Write No. 314 in Box on Inquiry Card

MUIRHEAD

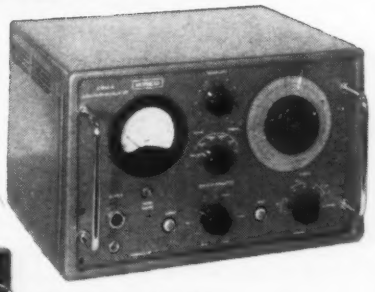


D-890-A (with crystal check)
Frequency: 1 c/s to 111.1 kc/s
Accuracy (max): 0.05%; 0.005% at spot frequencies.
Output (max): 126 v into 8k ohms or 24 v into 600 ohms.

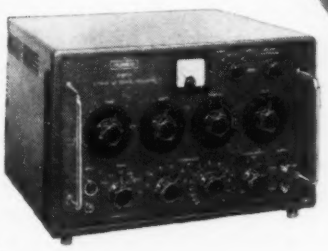


D-695-A
Frequency: 10 c/s to 31.2 kc/s.
Accuracy: 0.2% above 100 c/s; 0.3 c/s at 10 c/s.
Output: 10 v into 10k ohms; 2.4 v into 600 ohms.

Four of the most ACCURATE and STABLE variable-frequency OSCILLATORS



D-888-A (Analyser/Oscillator)
Frequency: 200 c/s to 650 kc/s.
Accuracy: 2%
Output (OSC): 2.5 v into 600 ohms.



D-880-A (2-phase)
Frequency: 0.01 c/s to 11.2 kc/s.
Accuracy: 0.2% above 5 c/s; 2% at 0.01 c/s.
Outputs: 10 v into 10k ohms and 600 ohms.

Models cover a frequency range from 0.01 c/s to 650 kc/s

WRITE TODAY FOR PUBLICATIONS 130, 136, 137 & 138

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PRECISION ELECTRICAL INSTRUMENTS

MUIRHEAD INSTRUMENTS INC., 441 Lexington Avenue, New York 17, N.Y., U.S.A.
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MUIRHEAD INSTRUMENTS LIMITED, Stratford, Ontario, Canada.
Telephones: 3717 & 3718
MUIRHEAD & CO. LIMITED, Beckenham, Kent, England.
Telephone: Beckenham 4888.
452/3

CIRCLE NO. 90 ON INQUIRY CARD

ELECTROMECHANICAL COMPONENTS

Timing Motors

Reversible timing motors incorporate automatic braking and clutching actions due to the axial shift of the motor when the coils are energized. De-energizing the coils results in a positive brake action rendering the motor particularly suitable for remote adjustments. Shift action can be modified to provide a free shaft when the motor is de-energized. This modification is primarily recommended for applications where the motor is required to have a positive drive when energized and no drag on the output shaft when de-energized. Bristol Motors, Old Saybrook, Conn.

Write No. 406 in Box on Inquiry Card

Heated Pneumatic Transducer

Electro-pneumatic transducer permits a valve actuator to be used with an electronic control system. Thirty-watt heater in the pneumatic section prevents freeze-ups in systems handling cryogenic fluids. The unit, designed to work with a primary-element transmitter and controller-recorder, is temperature compensated to maintain its calibration accuracy over a wide range of ambient temperatures. Crane Co., Swartwout Div., Hookset, N.H.

Write No. 408 in Box on Inquiry Card

Thermal Switch

Responding to tip temperature rather than shell temperature, precision thermal switches are most effectively used where inner temperature must be controlled. Operating within a temperature range of −20 to +550 F the switch employs a spring-loaded inner cartridge which is hermetically sealed. Reaction time is less than 0.5 sec. and temperature differential is from 1 to 2 degrees. Repeatability of operation is ±1 F. Weight is 0.9 oz. and over-all length is 2.5 in. Control Products, Harrison, N.J.

Write No. 409 in Box on Inquiry Card

Microminiature Sensitive Relay

Hermetically sealed sensitive dc relay, DPDT, withstands 20 to 2000 cps vibration, shock of 50g standard or better and temperatures from −65 to +125 C. Unit is rated from dry circuit conditions to 2 amps at 32vic with a minimum of 100,000 operations. Hi-G, Inc., Windsor Locks, Conn.

Write No. 417 in Box on Inquiry Card

Inertia Switch

Designed to function when G forces of appropriate magnitude, direction and duration are sensed, an inertia switch adapts to a wide range of acceleration and timing values. Upon application of forces of sufficient duration to complete the time function, the switch remains in the operated condition until it is manually reset to safe. It is designed for a temperature range of −40 to +165 F and for vibration of +15 Gs from 5 to 200 cps. Elgin Micronics, Chatsworth, Cal.

Write No. 360 in Box on Inquiry Card

Wire-Spring Relay

Fast-acting relay transfers up to 51 circuits for 100 million or more operations without readjustment. Actuating card operates all moving wire-spring contacts simultaneously and independently. The movable springs are aligned and anchored in a molded assembly and plastic comb aligns stationary springs. Automatic Electric Lab., Northlake, Ill.

Write No. 400 in Box on Inquiry Card

Flexible Wire

Elastic flexible wire, called Elasticable stretches to three times its relaxed length without losing any of its electrical properties. Commercial types have a natural rubber core with insulation of braided Nylon and conductors of copper magnet wire, bronze tinsel or copper tinsel. Elongation is 300% for a single conductor and 275% for multiple conductor cables. Military types have a silicone rubber core with insulation of braided Nylon and conductors of copper wire or bronze tinsel. Elongation is 250% for single conductors and 225% for multiple conductors. Natl. Radio Company, Melrose Mass.

Write No. 358 in Box on Inquiry Card

Rate Gyro

DC-powered gyro package, 2″ x 4″, contains a transistorized power inverter which eliminates the need for commutators, brushes, slip rings and governor contact points. Useful motor life is estimated to exceed 1000 hours. Besides supplying rate-of-turn output, inverter can be used as a source of 400-cps power for other gyros or frequency-sensitive devices. Frequency is controlled to ± 1 percent over the standard temperature range of −65 to +165F, with input voltage varying between 24 and 31 vdc. The gyro is available in ranges from ±15 to ±1000 degrees per sec. Giannini Controls Corp., Pasadena, Cal.

Write No. 361 in Box on Inquiry Card

Tandem Synchros

Synchro package combines any two synchros in the size 8 and 10 lines in a single size 10 housing 2.875″ long. Positive mechanical coupling assures zero lineup. Standard accuracies of 7′ max error are guaranteed. Clifton Precision Prods. Co., Inc., Upper Darby, Pa.

Write No. 414 in Box on Inquiry Card

Instrument Wire

Thin instrument wire in unlimited lengths, consist of stranded silverplated copper conductors from AWG 28 (7/36 stranding) to AWG 36 (7/44 stranding) with 1 to 6 mil Teflon insulation walls. Wire is rated for 300 volts at temperatures from −90 to +250C. Mechtron, Div. of Tensolite Insulated Wire Co., Inc., Peekskill, N.Y.

Write No. 413 in Box on Inquiry Card

Hi-Temp Connector

1000 F continuous duty connectors, AN 3100 and 3106, in sizes 16, 18, 20, 22, contain up to 19 contacts. Connector body and cable clamp are made of corrosion-resistant stainless steel. Ceramic insulators, standard contact coding and male and female units are available. Thermocouple may be Chromel-Alumel or any other specified material. Revere Corp. of Amer., Wallingford, Conn.

Proximity Limit Switch

Operating 3600 times per minute without physical contact with its actuating means, proximity limit switches have a long life expectancy due to absence of operating arms or springs. Hermetically sealed in a brass housing, the unit withstands temperatures from −50 to +250 F and is resistant to shock. Gen. Equipment & Mfg. Co., Louisville, Ky.

Write No. 405 in Box on Inquiry Card

Solenoid Valve

Direct-acting venturi-type valve, 1″ in size and weighing 1¾ lb, provides a straight-thru flow path without obstructions. Coils are unaffected by mechanical and thermal shock maintaining dielectric strength under salt spray and temperatures to 500F. Both valve and solenoid are rated from zero to 255 psi over an ambient temperature range of −65 to +250F with fluid temperatures between −30 and +350F and up to 550F for a maximum of 10 minutes. Valcor Engineering Corp., Kenilworth, N.J.

Write No. 365 in Box on Inquiry Card

New Electronic Components For Electromechanical Systems

Electronic Counters

With 0.1 v sensitivity, electronic counters directly measure frequencies from 10 cps to 1.2 mc, time intervals from 1 micro-second to 10^6 seconds and periods from 0.00001 cps to 100 kc. Stability is 2/1,000,000 per week. Readout is by six columnar neon indicators instead of inline digital display. The units also measure phase delay, random events, ratios and, when used with transducers, such physical variables as speed, weight, pressure, temperature and flow. Hewlett-Packard Co., Palo Alto, Calif.

Write No. 367 in Box on Inquiry Card

Frequency Standard

Designed to provide a stable secondary frequency source of 400 cps, a frequency standard is basically a crystal controlled oscillator synchronizing a relaxation type oscillator which drives a binary. The binary in turn drives a tuned power output stage or a square wave amplifier. The solid state unit (1½" x 2¼") weighs 4.5 ozs. and the entire assembly is dip-potted for sealing and rigidity. Output does not vary more than ± .015% over a range of −55 to +100C. Time Control Systems Div., Designers for Ind., Inc., Cleveland, Ohio.

Write No. 359 in Box on Inquiry Card

High-Power Attenuator

Designed to feed two different power leads to an antenna, a switch attenuator ranges in values from tenths of a db to 20 db and up. It is supplied with a high-power isolator and, in most applications, may be switched without turning off the transmitter. An external holding resistor allows indefinite periods of actuation without excess heating of the switch mechanism. The unit is pressurizable, and is available for most frequency ranges and waveguide sizes. Bogart Mfg. Corp., Brooklyn 6, N.Y.

Write No. 362 in Box on Inquiry Card

Self-Locking Captive Nuts

The ease with which stainless steel machined inserts are applied and their reliable grip in the parent metal as well as their self-locking ability make them ideal for a wide variety of applications. Hexagonal in shape, the thread sizes are 4-40, 6-32, 8-32 and 10-32, and are designed for material thicknesses of 1/16, 3/32, 1/8, 3/16 and 1/4 inches. All sizes have a passivated finish, per MIL-P-12011. National Radio Co., Malden, Mass.

Write No. 184 in Box on Inquiry Card

Instrument Tubes

Electron tubes designed specifically for instrument manufacturers, exhibit tight, stable characteristics, long life and incorporate the most advanced military reliability features, except for unnecessary shock and vibration controls. Tight limits are maintained for transconductance, plate current, cutoff, contact potential, and balanced triode characteristics. Undesirable characteristics such as microphonics, hiss noise and leakage currents are minimized. Satisfactory operation at low and high line voltages is assured by controlled cathode activity. CBS Electronics, Danvers, Massachusetts.

Write No. 302 in Box on Inquiry Card

Decade Counter

Grounding one of two control lines on a transistorized decade counter determines whether unit will add or subtract. Counter is available in a single voltage model requiring 100 v at 40 ma, or a lower dual voltage model requiring 30 v at 35 ma and 60 vac at 1 ma. Units contain a ten number display, electrical zero reset and optional coincidence output. Robotomics, Inc., Phoenix, Ariz.

Write No. 507 in Box on Inquiry Card

Solid State Commutators

Designed for airborne sampling of low level differential instruments such as strain gages and thermocouples, electronic commutators contain up to 90 differential channels in high density packages. A 30 channel unit weighs 2.5 ozs. an dis less than one in. in volume per channel. Units incorporate all necessary power converters and programming circuitry. The commutators sample at a rate up to 10,000 per sec. at an accuracy of 1% or better with full scale input levels at 5 millivolts or greater. General Devices, Inc., Princeton, N.J.

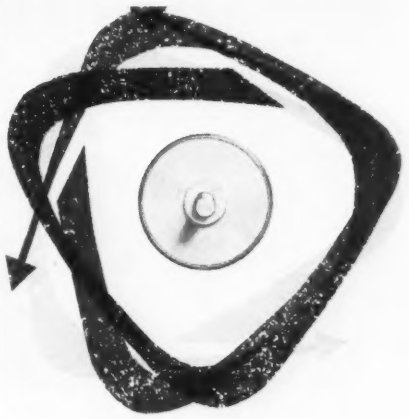
Write No. 509 in Box on Inquiry Card

Magnetic Shift Registers

Using only one core per bit, magnetic shift registers achieve non-destructive readout, reversible data-flow and counting code generation and "corner-turning". Use of "wide-width" bit-coupling permits controllable-width output pulses with operation essentially independent of shift-pulse width and minimum shift-pulse power. Registers are available in 5-bit, 9-bit, and 10-bit length/module, and may be combined without limit, since each module contains its own shift drive, wide-width gate and hold-gate circuitry. Magnetics Research Co., White Plains, N.Y.

Write No. 508 in Box on Inquiry Card

ROTARY DC SOLENOIDS



PRECISION ROTARY MOTION

Where high torque and smooth precision, rotary motion is required.

DESIGN FEATURES

Low torsional inertia • No axial shaft movement • Any degree of rotation, CW or CCW up to 60° • Withstands severe shock and vibration • Permanent lubrication • Any DC voltage range • Custom engineered torque-stroke • Terminals & mountings to specific requirement • Minimum residual effects in magnetic structure • Short rotary strokes where required • High torque output • Long life.

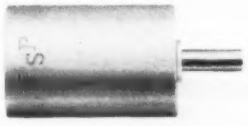
SPECIFICATIONS

Operating voltages from 6 to 300 VDC, with rectifier assemblies available for use of AC at standard commercial frequencies. Stroke length and torque curve to specification, with CW or CCW rotation. Units can be supplied with multiple windings for hold-in, with or without switching devices. Intermittant or continuous duty models available, in sizes 8, 10, 13, 15, and 18.

APPLICATION FEATURES

Engineered for applications where high torque, and smooth, precise rotary action is required • Can be specified for severe applications involving extreme temperature and pressurization • No axial shaft movement • Rotation may be limited prior to stroke completion • Special shape configurations and mounting features to specification • Strict adherence to aircraft or military quality and performance.

For additional information, write for bulletin 211.

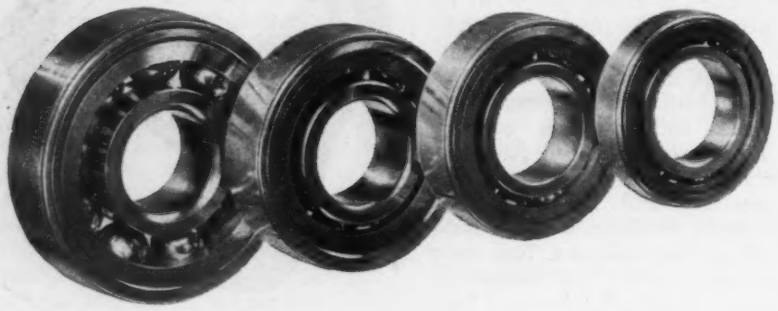


Division of IMC Magnetics Corp.
6058 Walker Avenue • Maywood, California
LUdlow 3-4785 • TWX LA 1664-U

PSP ENGINEERING CO

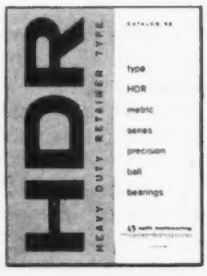
CIRCLE NO. 92 ON INQUIRY CARD

NEW HEAVY DUTY (HDR) PRECISION BALL BEARINGS



A significant step forward in bearing technology. These precision bearings combine the advantages of a maximum ball complement with deep groove ball races uninterrupted by filling notches or counterbore. The result is a new kind of ball bearing with superior performance characteristics. Up to 56 percent more capacity than conventional Conrad type ball bearings; or, in terms of life, up to 280 percent more. Also greater rigidity, less deflection, and increased resistance to shock loads. Made in standard metric series and sizes, to ABEC-3 and ABEC-5 grades of precision.

Find out for yourself —
write today for catalog 60.



split ballbearing
A DIVISION OF MPB, INC.
524 HIGHWAY FOUR, LEBANON, NEW HAMPSHIRE

CIRCLE NO. 64 ON INQUIRY CARD

ELECTRONIC COMPONENTS

Inverters

High capacity static inverters and converters offer reliable, highly regulated power of precise frequency and use direct frequency control and digital logic circuits to produce single or polyphase power output without moving parts. Capacity ranges from 150 to 4000 volt-amps and the efficiency range is from 65 to 90% depending on power and control required. Phase control is accurate to 0.5 degree. Frequency control up to 6 parts per million maximum variation under all load and environmental conditions is attained. Delco Radio Division, Kokomo, Indiana.

Write No. 300 in Box on Inquiry Card

Analog Integrator Networks

Operational-amplifier integrator networks achieve a high level of accuracy and stability over wide temperature ranges. Unit consists of from one to 18 input branches and a feedback capacitor in an oil-filled hermetically-sealed can. Trimmed capacitors have negligible leakage and a minimum of dielectric absorption, temperature and voltage retrace. Maximum one-year drift in rc product is ±0.01%. Julie Research Lab., N.Y., N.Y.

Write No. 356 in Box on Inquiry Card

Counting Indicators

Displaying 4½" numbers; counting indicators accept input pulses, register the decimal count, and generate an output pulse at count of ten to drive the next indicator. There are no bulbs to burn out since high light-levels are produced with neon gas tubes. Numerals are easily observed at distances over 100 feet and at angles up to 70°. Counters and decoders are all semi-conductor, requiring very low power and voltage. Navigation Computer Corporation, Philadelphia, P.A.

Write No. 303 in Box on Inquiry Card

Glass Shapes

An extended line of glass beads and other shapes for glass-to-metal seals includes over 10,000 various shapes and sizes. Formulations of the glass meets exact fabricating and operational temperatures of finished glass-to-metal seals. Mansol Ceramics Co., Belleville, N. J.

Write No. 502 in Box on Inquiry Card

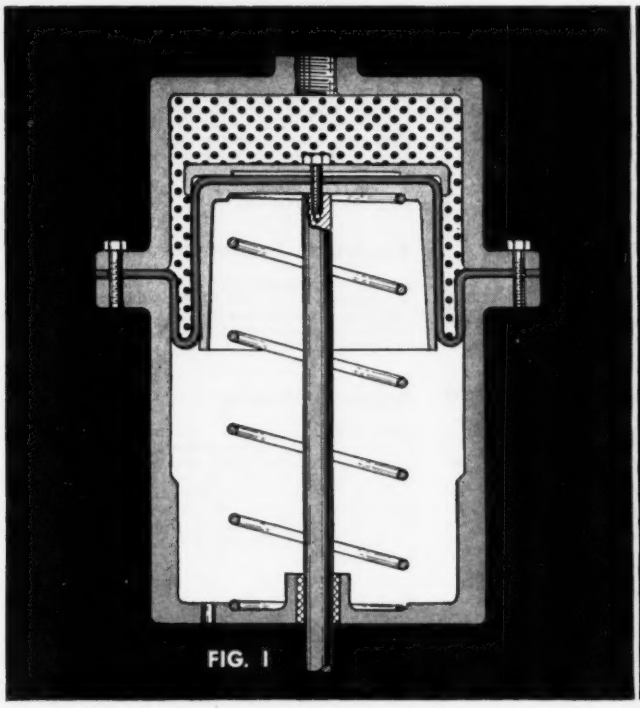


FIG. I

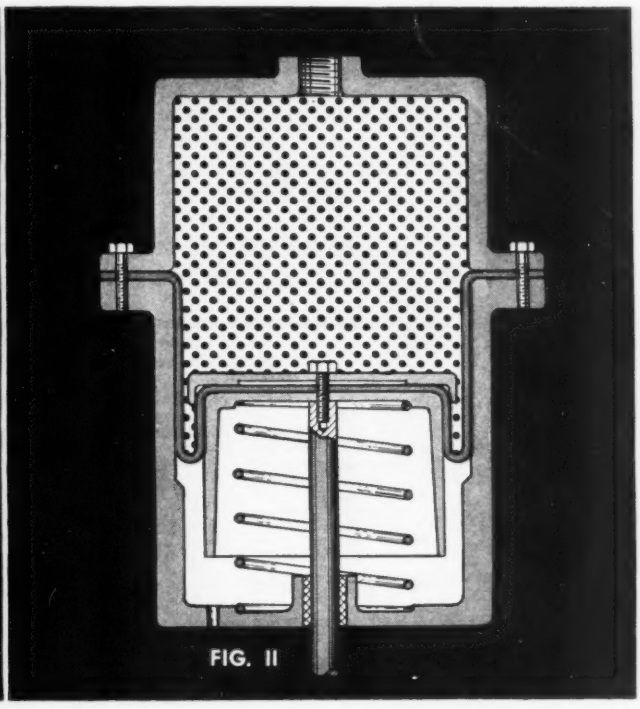


FIG. II

For Hydraulic and Pneumatic Devices

Nothing rolls like a Bellofram®

Rolling Diaphragm. It's frictionless!

The Bellofram Rolling Diaphragm provides ultra-sensitive response in hydraulic or pneumatic devices where frictionless, long-stroke action in small diameter configurations is required . . . and where flex life of millions of cycles is necessary.

These desiderata are achieved through the *rolling* action of a flexible, thin-sidewall diaphragm consisting of a high-tenacity fabric overlay embedded in elastomeric material.

Fig. I shows how Bellofram Rolling Diaphragm conforms to the piston. Fig. II shows how, as the piston descends under pressure, the Bellofram Rolling Diaphragm *rolls* off the piston's sidewall and onto the cylinder's sidewall in a smooth, continuous, frictionless movement.

The Bellofram principle can be applied widely in actuators, pumps, instruments, seals, accumulators, and fluid dampers.

Which of these advantages are you looking for?

To the designer confronted with situations for which conventional bellows, O-rings, or cup packings are inadequate, Bellofram Rolling Diaphragm offers a constellation of advantages found in no other product:

1. **Friction-free (low hysteresis).**
2. **No break-out friction effects.**
3. **Non-porous and leakproof.**
4. **Constant area in all piston positions.**
5. **Almost infinite flex life (millions of cycles).**
6. **Sensitivity to extremely small pressure changes.**
7. **No mechanical spring gradient.**
8. **Compatibility with practically all environmental gases or fluids.**
9. **Automatic de-icing action.**
10. **Free positioning with complete relaxation at any point in the stroke.**
11. **Does not require close machine finish tolerances on pistons and cylinders.**
12. **Freedom from abrasive wear.**
13. **One hundred stock sizes. Four mounting configurations. Special types and sizes designed to order.**
14. **Excellent temperature stability from —85°F. to 550°F. (from —120°F. to 700°F. in some cases). Wide range of working pressures: 1 inch H_2O to 500 psi (up to 1200 psi in some cases). Effective pressure areas from .028 to 108 square inches. Cylinder bore diameters from .25 to 12 inches. Extended range of stroke (.01 to 12 inches).**

SEND FOR FREE LITERATURE

Bellofram Rolling Diaphragms are protected by U.S.A. and foreign patents.

Bellofram®

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Bellofram Corporation, 30 Blanchard Rd., Burlington, Mass.

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Company .....

Street.....City.....State.....

I am interested in (*state application*).....

.....

For Your 3-Ring Binder

NEW DATA SHEETS

For your free copy of the data sheets listed on this page, enter the appropriate number of the item on the Inquiry Card.

Test Control System 472

Subjects of a 4-page brochure are two systems working together; a control system for precise adherence to a programmed series of test parameters, and one for data acquisition and processing. An integral part is an automatic, high speed, analog-to-digital converter system. Consolidated Electrodynamics Corp., Pasadena, Calif.

Switch Lights 473

Switch light rebulbs from front without use of tools and has all its terminals at back of assembly. Lamp and switch circuits are independently operated and all units meet mil. specs. Master Specialties Co., L.A., Calif.

Silicon Power Transistors 474

Diffused-junction, NPN silicon transistors for high power switching and amplifier applications, operate in the temp. range of —65° C to +200° C. Maintaining electrical and mechanical stability, these units meet the environmentals of MIL-S-19500B. Silicon Transistor Corp., Long Island, N.Y.

Miniature Oil-Less Vacuum Pumps 475

Miniature, oil-less vacuum pumps and air compressors for use where space and weight are restricted, were designd for automatic controls, instruments, business machines and lab demonstration equipment. Self-lubricating carbon vanes produce completely oil-free air blasts or exhaust. With a rotor diameter smaller than a penny, one air pump model weighs only 11 ounces less motor. Gast Mfg. Corp., Benton Harbor, Mich.

Infrared Spectrophotometer 476

Low cost spectrophotometer provides high resolution runs in the significant near-infrared wavelength region between .83μ and 7.65μ. Instrument uses two diffraction gratings, each in the first order, to cover wavelength range and permits an 8-minute program for rapid survey work, or a 24-minute scan for maximum resolution of fine structure. Perkin Elmer Corp., Norwalk, Conn.

Precision Resistors 477

One-watt and 7-watt sizes have been added to a line of precision resistors that feature a jacket of tough, resilient, silicone-ceramic material molded over a wirewound, tubular ceramic core. Ohmite M'fg. Co., Skokie, Ill.

Recordeer/Reproducer 478

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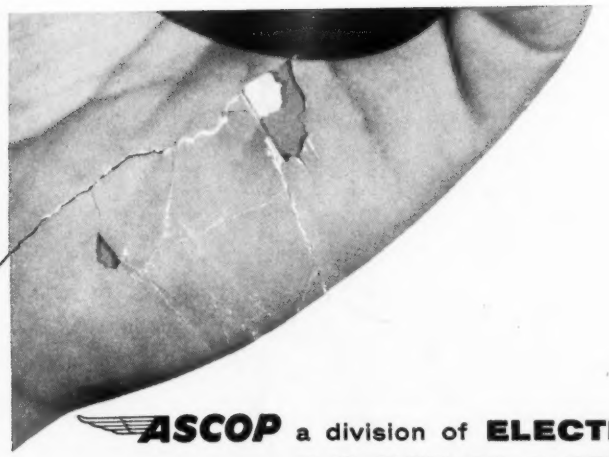

Total Count: 2^{13} achieved in 64 turns of input shaft
Size: ..... 2¼" dia. x 3⅛"
Code: ..... Binary with lead-lag heads
Output: ..... Parallel
Weight: ..... 16 ozs.
Inertia: ..... 70 gm-cm²
Breakaway Torque: ..... 0.05 in. oz.
Max. RPM: ..... 10,000 rpm
Expected Life: 20,000 hrs. at 4000 rpm (expected bearing and gear life)

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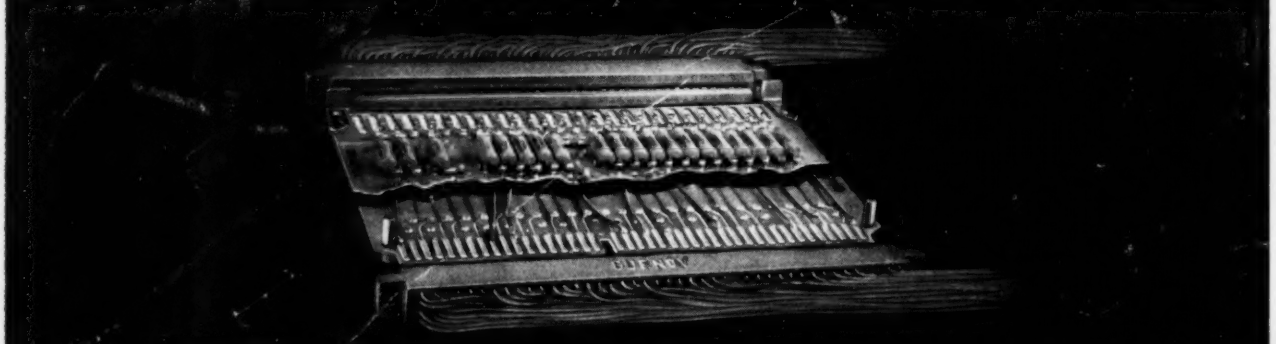

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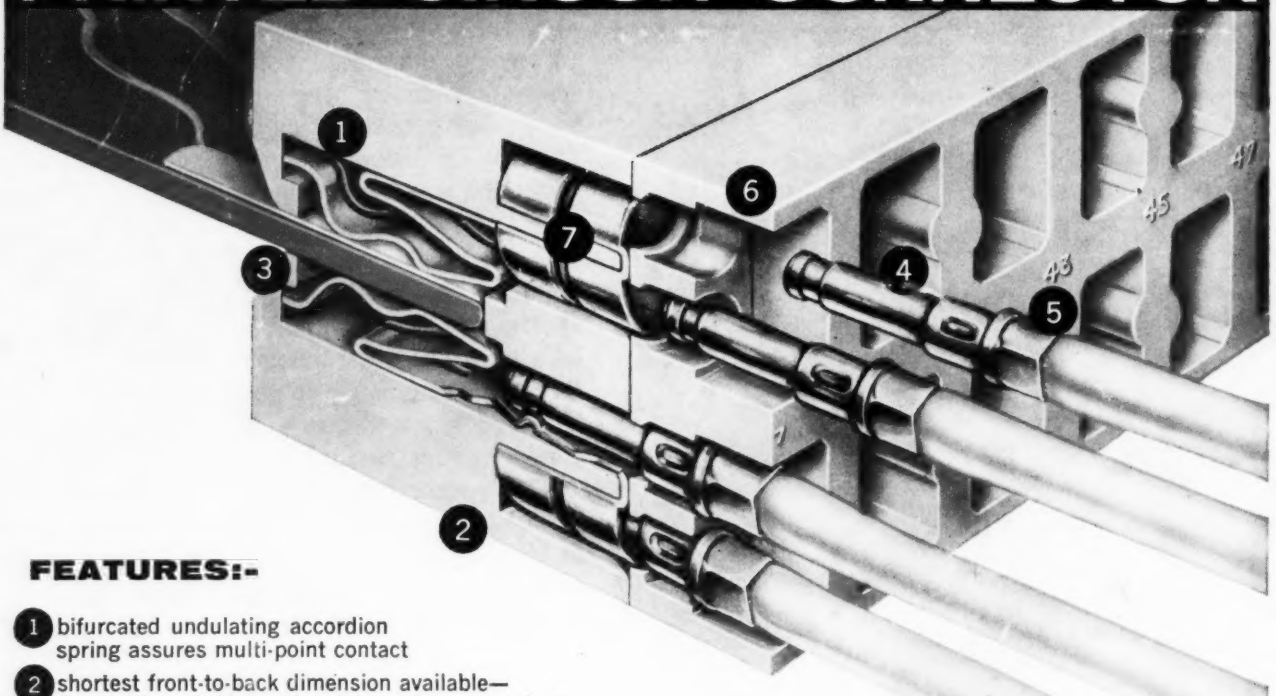

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Test Control System 472

Subjects of a 4-page brochure are two systems working together; a control system for precise adherence to a programmed series of test parameters, and one for data acquisition and processing. An integral part is an automatic, high speed, analog-to-digital converter system. Consolidated Electrodynamics Corp., Pasadena, Calif.

Switch Lights 473

Switch light rebulbs from front without use of tools and has all its terminals at back of assembly. Lamp and switch circuits are independently operated and all units meet mil. specs. Master Specialties Co., L.A., Calif.

Silicon Power Transistors 474

Diffused-junction, NPN silicon transistors for high power switching and amplifier applications, operate in the temp. range of —65° C to +200° C. Maintaining electrical and mechanical stability, these units meet the environmentals of MIL-S-19500B. Silicon Transistor Corp., Long Island, N.Y.

Miniature Oil-Less Vacuum Pumps 475

Miniature, oil-less vacuum pumps and air compressors for use where space and weight are restricted, were designd for automatic controls, instruments, business machines and lab demonstration equipment. Self-lubricating carbon vanes produce completely oil-free air blasts or exhaust. With a rotor diameter smaller than a penny, one air pump model weighs only 11 ounces less motor. Gast Mfg. Corp., Benton Harbor, Mich.

Infrared Spectrophotometer 476

Low cost spectrophotometer provides high resolution runs in the significant near-infrared wavelength region between .83μ and 7.65μ. Instrument uses two diffraction gratings, each in the first order, to cover wavelength range and permits an 8-minute program for rapid survey work, or a 24-minute scan for maximum resolution of fine structure. Perkin Elmer Corp., Norwalk, Conn.

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